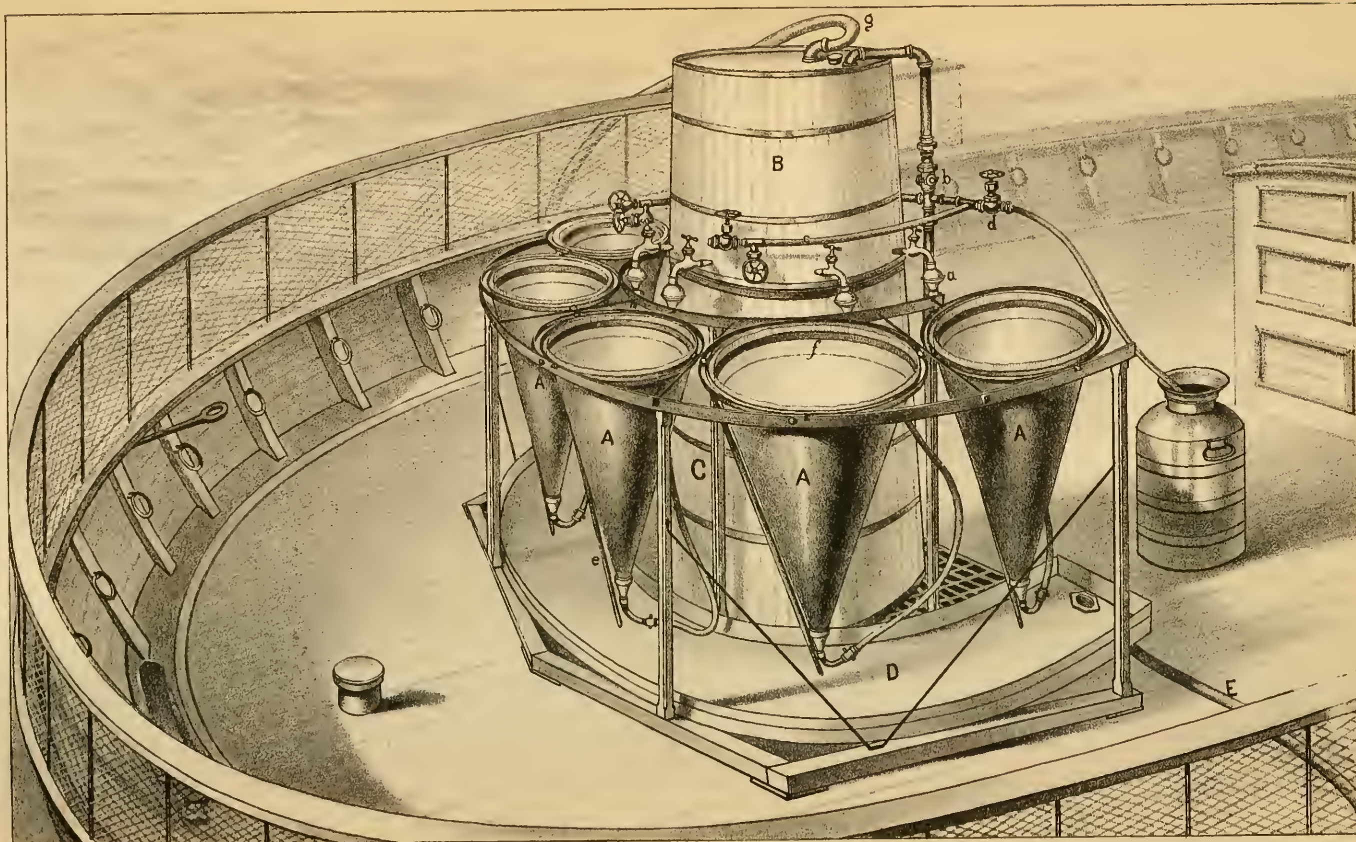

g
B
b
d
a
f
A
A
A
A
C
e
D
E

20

Document [—.]

BY THE HOUSE OF DELEGATES,

JANUARY 10th, 1878.

Which was read and ordered to be printed.

By order,

MILTON Y. KIDD,
Chief Clerk.

REPORT

OF THE

COMMISSIONER OF FISHERIES

OF

MARYLAND,

JANUARY, 1878.

ANNAPOLIS:
GEORGE COLTON, PRINTER TO THE GENERAL ASSEMBLY.
1878.

REPORT.

To his Excellency,

JOHN LEE CARROLL,

Governor of Maryland:

I have the honor to report, in pursuance of section 4, chapter 47, laws of 1876, "the work accomplished by the Commission" during the year 1877, and to make a few "suggestions for the protection and propagation of the food fishes of the State," as the result of my observation and experience during the four years of service as Commissioner of Fisheries.

The past year has been a most important one, to the fishing interest especially, as producers, and to the country at large, as consumers of fish, on account of the many indubitable proofs which have accumulated, showing the correctness of the theories on which most of the efforts to restore depleted waters with the valuable fishes, which were once abundant, but had either entirely disappeared, or had become alarmingly scarce, depended for success. On the correctness of these theories depended also the success of any efforts to stock waters with migratory fishes, which had before been unknown to them. The year 1877 will be noted as adding confirmations so strong that even the hitherto most skeptical can no longer doubt the unerring certainty with which the anadromus fishes (those fishes which move up the rivers to spawn,) return, when adult, to the river in which they had spent their minority. That this was the habit of the Salmon, had been demonstrated both in Europe and in this country, as great numbers had been marked and found to

return to the same river, year after year ; but the experiments had, in a great measure, been confined to rivers or localities in which the Salmon had been previously found. During the year just ended, we have had many proofs that this instinct is so strong that the Salmon will return to rivers, in latitudes in which they had never existed prior to their artificial introduction as young fish.

Mr. Wilmot, Fishery Officer of the Dominion of Canada, writes me : "California Salmon have visited my establishment this Autumn for breeding purposes."

Hon Theo. Lyman, Commissioner of Mass., writes : "The most striking and rapid restoration of a partially exhausted fish, was that of our common Smelt, (*Osmerus*), which we value much, and which we again have in its former size and abundance.

A very important fact is the return this year, and for the first time, of large numbers of adult Salmon, (*S. salar*), the progeny of artificial culture, to the Merrimack river.

Small lots of Salmon parrs had been placed in the upper waters on several occasions previous to 1872. In that year, 16,000 were put in ; and in 1873, 185,000.

This year (1877,) we ordered our agent at Lawrence, to shut the water from the great fishway *daily*, and see what was in it at the moment of closing.

On May 31st, he found two Salmon of 8–12 lbs. weight. On June 4th, a 15 lb. Salmon. From June 10th to July 10th, there were found, almost daily, from 1 to 5 large Salmon in the act of passing the way at the moment of closing. They penetrated to the very head-waters, among the White mountains, and were seen shooting the falls in numbers. Many were taken, for a moment, in a net and examined, and were found to be high-fed, silvery fish of the first quality."

Dr. Wm. M. Hudson, of Connecticut, adds the following testimony to the return of the Salmon : " The young of the *Salmo salar* from Bucksport, first introduced in 1871, ap-

peared as Smolts within two years after their introduction, and specimens were easily obtained. About a dozen of the adult fish have been taken in the Connecticut river during the past season."

But to us in Maryland, of more importance is the re-appearance, in the Delaware, of Salmon of both varieties: the *Salmo salar* of the northern Atlantic coast, and the *Salmo quinnat* of the Pacific. I have received authenticated accounts of the capture of one weighing 8½ lbs., at Newcastle; one, 8¼ lbs., at Riverton; and one weighing 9 lbs., taken between Bordentown and Trenton; and have myself seen a large female Penobscot Salmon, with the mature eggs running from her, which was taken near Easton, in the act of spawning; there have been several others reported, even weighing as high as 20 lbs. These indications of the successful introduction of the Salmon into the Delaware, commenced two years prior to the establishment of a Fish Commission in Maryland, strengthens our hopes and confidence in the results of our efforts, as the Delaware is not so unlike our own rivers, and not in so different a latitude but that we can reasonably expect a like result. More important to us still, than the accumulated evidences of the laws which govern the migrations of the Salmon, are the proofs which have been added during the year, that these laws are as surely applicable to the migrations of the Shad

It may be possible to attribute the return, in comparatively large numbers, subsequent to artificial propagation of Shad in a river, while in adjacent rivers they continued to decrease, to other causes than the production of a large number of young fish, which, without artificial means would have been entirely destroyed. It is impossible, however, to account for the sudden appearance of Shad in a river in which they had not hitherto existed, but in which young Shad, artificially propagated, had been placed, on any other theory than that of their return to the waters of their youth,

impelled by the same instinct which has been so clearly demonstrated as governing the Salmon. Such unmistakable evidence have we in the capture of several hundred adult white Shad, *Alosa sapidisima*, in the Ohio river last spring, since prior to their introduction in 1872, by the United States Commissioner, this most valuable fish was unknown to the Mississippi river, or any of its tributaries. Add to this the successful introduction of Shad into the rivers of the Pacific slope, and we are forced to the conviction that the same laws are applicable to the return of the Shad as to the Salmon, viz: that they will return as adult to the waters in which they are placed when young.

On page 22 of the report of the Commissioners of Fisheries of the State of California for '76 and '77, they say: "Shad, in their season, are becoming quite numerous in the Sacramento river. The experiment of their importation to this coast has resulted satisfactorily. The river is of proper temperature, and furnishes an abundance of food for the young fish before they go to the ocean. There can be no doubt that the first Shad brought from the Hudson river, in eighteen hundred and seventy-one, have been to the ocean, returned and spawned."

The introduction of Shad into the rivers flowing into the great lakes has also proved as completely successful, although it was feared that they would not find in the fresh waters of the lakes, conditions as suitable as in the salt water of their accustomed abode in the Atlantic. During the past season, many fine large specimens, weighing as much as five and a half pounds, were taken in the tributaries of Lake Ontario. The dates of the original deposit of the young fish in the waters in which they had hitherto been unknown, and the times of their subsequent re-appearance as adult, give us some evidence, also of the probable growth, of the variety of fish. In these instances of the successful introduction of Shad in California, in the Ohio and in the Great Lakes, the first deposits having been made in 1871, 1872 and 1871 respect-

ively, indicate, that with the Shad at least, that they do not return from the sea in numbers as adults before the 4th, 5th, or perhaps the 6th year. The imperfect means of observation causes these deductions to be mere conjecture, but sufficiently important to sustain hope and confidence in the ultimate successful results from efforts to re-stock our waters with this valuable fish, even though no decided increase is observable for four or five years after the initiation of the work. In judging of the efficiency of the means employed to re-stock our waters with Shad, we must not lose sight of the fact that there has been an enormous, alarming and steady *decrease* in the yield of our Shad and Herring fisheries since forty years back, when the catch on the Potomac in *one day* was equal to the entire catch of last *season*. Surely, if this decrease can be arrested only, even if there is no marked increase for several years to come, the work of artificial propagation, as yet scarcely more than begun, should be prosecuted with the utmost energy.

It was not to be expected that we should have any positive evidence of the success of the introduction of Salmon, or the increase of Shad, resulting from young fish artificially propagated and placed in our waters, as a sufficient time has not elapsed since the commencement of the work in Maryland; but we are not without indications of what will be the result of continued efforts to increase our fish yield. As it has been pretty well ascertained that the male Shad are adult, and run up the rivers a year sooner than the females of the same brood, which are not mature until the 3d or 4th year, I looked with some certainty for an increase of numbers in the Bay of smaller male Shad, consequent to the return of some of the males of the one million seven hundred and ninety-five thousand turned loose in the Chester river, and the two million three hundred and fifty-five thousand turned loose in the Patuxant during the spring of 1875. It having been observed with the Salmon, that the youngest fishes arrive earliest in the season, but do not penetrate far the first

year, I thought it most likely that the return of the young Shad would first be noticeable in the Bay, so visited the Annapolis Fish market on Saturday, April 21st, and examined many of the fishermen operating the large pound nets in that locality, and the universal testimony given by them was that the catch of small "buck Shad" had been larger than known for many years, some asserting that they had not taken so many male Shad for twenty years, while the females were not more abundant than in previous seasons. If this increase in the number of males is attributable to the operations on the Chester in 1875, as we have every reason to believe that it is, a corresponding increase in the females can be looked for during the coming seasons.

The great success attained by artificial means in the Connecticut, Hudson and other rivers, has already been instanced in my previous reports.

The National Museum at Washington, has a case devoted to the preservation and exhibition of specimens, showing the success in stocking waters of the country with fish by artificial methods. This case is constantly, almost weekly, receiving additional specimens from all parts of the country, testimonies to the successful efforts of Prof. Baird, United States Commissioner, and of the several State Commissioners.

Apace with the accumulation of evidence to the correctness of these theories, on which the efforts to increase the fish-food resources of the country were based and the proofs of the good results already attained from these well-directed efforts, is the progress which has been made during the year in the methods, and the improvements in the apparatus employed and necessary for the successful prosecution of this important industry.

In other States, there have been several important improvements made in the apparatus used during the development artificially of the ova of fish, and in the methods of packing eggs for transportation. In Maryland, we have overcome some difficulties with which our natural surround-

ings threatened to obstruct our efforts to restore Shad to their former degree of plenty. We have been able, during the season, to thoroughly test the apparatus, used to transport the shad eggs from distant fisheries to a central hatching station, to completely develop the eggs when not convenient to transfer them, and to transport the young fish after they are freed from the eggs—referred to on page 8 of my report of January, 1877. We perfected this apparatus, in its detailed arrangements, and so successful was its use during our operations at the head of the bay last spring, that we deem it worthy a more minute description, which will be found, in the account of the Shad hatching work, on another page.

The more important apparatus, of which the above was auxiliary, is that used at the central station, capable of perfecting an almost unlimited number of eggs safely, without danger from storm, independent of current, and at comparatively small cost. This apparatus, original in design and novel in construction, is fully described in the drawings and specifications of the patent granted by the United States Patent Office; these are reproduced in the account of Shad-hatching operations.

For the third apparatus, which marks the advance in fish culture in Maryland during the year, we are indebted to Mr. Thomas Winans, of Baltimore, whose thoughtful study of their habits, and observations of the Brook Trout hatched in his dwelling during the winter, resulted in his devising an apparatus in which to feed the young fish. The Trout kept and fed in this apparatus attained, at three months, a size at least double that of those of the same brood which were kept and fed in the usual nursery tanks. Mr. Winans kindly presented the Druid Hill Hatching House with a number of these vessels, with all the necessary appliances, ready for the introduction of the water. The device consists in the use of an ordinary apothecaries' filtering funnel, fitted to a frame, which keeps it in position; a rubber

tube is slipped over the neck, through which the vessel is supplied with water, which flows out through a screened aperture near the top. The current, which is caused by the passage of the water through, is so regulated in force as to keep the particles of food thrown in, suspended about midway, constantly in sight of the fish, and easily attainable by them. The food is consumed without being deposited on the bottom, as in the ordinary nursery tanks, where it remains, uneaten by the fish, and, unless carefully removed, to putrify and vitiate the water. By the use of these glass-funnels, the movements of the fish are plainly visible, and the exhibition of those reserved for experiment and illustration, made attractive. Such was the success from the use of these glass-funnels, that we are about to introduce them on a considerable scale in the Hatching House. Those presented by Mr. Winans are about the maximum size that can be constructed of glass. But as the fish increase in size, we will use the inverted cones, such as illustrated in the account of the Shad hatching operations. These, though having the advantage in cheapness and capacity for greater size, are, of course, opaque, and not so attractive. Although vessels of the inverted cone form had been used for four years by us, for the purposes of propagating fish, to Mr. Winans is due the credit of first placing this form of vessel to the use of rearing as above described.

The evidences of the success of the work in other States, and the indications of the success, which can be confidently looked for in time, in our own State, have taught us that we are not pursuing a vain or idle fancy; that the energy which has inspired most of those who have entered upon the prosecution of this comparatively new industry, is not the energy of wild enthusiasts, but the vigorous action which truth inspires, and the consciousness of the good which will result to the country, and the benefit to mankind by a greater production of healthy and cheap food.

We, have not only learned that we are doing the right thing, with reasonable hope for success, but, by the advance made in the methods and apparatus above referred to, have found how best to do it; but almost as important as these, is the increased interest which the people take in the work of the Commission. The gathering of spawn at points easily accessible to the people; the development of the ova in so public a place as Druid Hill Hatching House, where every one is cordially admitted, so that every stage of that development can be seen, and the gradual changes watched; the distribution of the young fish; the successful conduct of Shad hathing at the head of the bay, where all so disposed could see, and the constant reports which the press of the State have given, have tended to cause the people to think earnestly, and give the subject more thoughtful consideration than heretofore. The consequence is, that fish are no longer looked upon as spontaneous and inexhaustable products of the waters, and it is no longer deemed the first duty of every one to take and kill every fish seen, whether needed for food or not. With this more just appreciation of the origin, and the natural laws which govern the growth and existence of fish, comes the desire for their protection, that they may be tributary to our comfort, and a never failing means to our support. Thus, hand in hand with fish culture, should come intelligent and systematic protection, so necessary for its success.

The full results can never be derived from the artificial propagation of our food fishes, unless aided by legislative protection; but no protective laws rigidly enforced, short of a total suspension of fishing, unaided by artificial propagation, can restore our Shad and Herring fisheries to their former glory. The Shad and Herring are taken together, except in the gill nets, and they commence to spawn, the Herring first some two weeks after they appear, and the spawning season extends through the spring. It is, therefore, impossible to protect them in their spawning time, ex-

cept by not taking them at all ; for their capture is not possible at any other time. After an individual Shad or Herring is taken, that's an end of it ; there is no way of saving him or her, even if found ready to reproduce, let the captor be ever so disposed to do it. But the Shad and Herring are enormously prolific, the Herring more so than the Shad ; or rather they each have great capacity for reproduction ; but that the results from the natural production of those fish which escape, are at all approximate to the number of eggs contained in the ovaries is very doubtful. I am inclined to think that by far the greatest loss, with this class of fish, is during the egg state. It is impossible to make any estimate as to the percentage of loss of eggs from unimpregnation, destruction by sediment, and by being preyed upon by Eels and other fish, but it must be very large. In very many cases where nature is most lavish as to numbers, does she permit the greatest waste, and with many of the fishes, we can observe that the natural protections given the eggs are inversely as the number produced by the parent. The male of some of the *Siluroids carry the half doz. or so eggs deposited by its mate in the mouth, and care for them until developed ; whereas the thousands produced by the Shad are left to be preyed upon by every passing fish. The Salmon yield much fewer eggs than the Shad, and they are apparently much more carefully deposited by the fish, and with much better chances of becoming impregnated by contact with the milt than the Shad eggs, yet Mr. Myron Green, foreman of the United States Commission Hatching Station on the McCloud river, found that not more than eight per cent. of the eggs naturally spawned were fertile. See report of Commissioners Fisheries California, 1877, page 12, for this statement : " After throwing out all the eggs found not to be fecund, there were left eight per cent. of the whole number gathered, which were found to be fertile. When eggs and milt are artificially brought in contact out of the water, it

*_Arius fissus, A. Boakii._

would be carelesness or inexperience that would prevent ninety-five per cent. of the eggs from being fertilized."

The great loss of eggs from causes above referred to, makes it necessary that a very large number of breeding fish should be left to spawn, so as to provide for the yearly consumption.

As the eggs which are hatched artificially are taken from the fish after they are practically dead and *en route* to market, the young fish derived from this source are a clear gain, and must ever be an important addition to whatever numbers may be produced by stringent protection.

HATCHING HOUSE.

During the year, the Hatching House has been much improved and the interior repainted; the filtering tank in the house has been much enlarged, so that the Spring water can be more slowly and thoroughly cleansed of sediment, and separate filtering tanks have been constructed on an adjacent hill, in which the water derived from the city reservoir is filtered before being introduced into the building. The elevated position of these filtering tanks has enabled us to carry the water into the second story; the two rooms formerly occupied by the attendant have been thrown into one, and will be used hereafter as a nursery and hatching room, adding very materially to the capacity of the house. The regular routine work connected with the care of spawn of the fall and winter spawners, and the distribution of the young fish when sufficiently advanced, was conducted during the winter of '76 and fall of '77, with the usual success. On the 1st of May, I found it necessary to transfer the force of trained men to the Shad-hatching station, and work in this department ceased until fall, when active operations commenced with the receipt of 200,000 eggs of the California Salmon.

The details of the distribution of fish from the eggs received in the fall of '76, and not included in the last

report, that is, from January 1st to June 4th, amounted to 31,000, as will appear from the tables hereafter given. These, with the distribution made in the fall of 1876, amounting to 784,640 (see pages 22 and 23 of report of '77,) make an aggregate of 815,640 from the eggs received in the fall of '76.

On the 10th day of October last, I received, through the kindness of the United States Commissioner, a crate of Salmon eggs, containing about 200,000; on unpacking, only 6,689 dead eggs were found, a very small loss during the transfer across the continent. The distribution made of the young fish hatched from this lot will appear in subsequent table. There are still at the Hatching House, about 10,000 young fish, which have been kept for future distribution and experiment.

The loss of young fish from this lot of eggs was unusually large. The weather was unusually warm when the eggs were laid down, and the water being unusually warm, the fish were perhaps prematurely hatched.

There are now in the hatching apparatus about 180,000 eggs of this fish, also a contribution from Professor Baird, and when hatching and ready for distribution, will be disposed of as usual. These are eggs which were received in two lots by express from California—one of 100,000 on December 5th, only 1,430 having died en route; the other lot of 80,000 reached the Hatching House on the 13th. They were taken, as I understand, from younger fish, which spawn later in the season, and after the regular operations of the United States Commission on the McCloud river had ceased; the eggs arrived in good condition, and are considerably larger than any eggs of the California Salmon yet received. Of the 2d lot of 80,000, only 2,525 were found to be dead when they were unpacked.

The total number of California Salmon planted during the two years ('76 and '77,) 911,040, recorded in last report, and

150,500, as will be seen from table, is 1,061,540; if to these are added 170,000 for the produce of eggs now in the Hatching House, as these will be distributed during the Winter, we have an aggregate of 1,131,540 California Salmon planted from the eggs of 1876 and 1877, and since the commencement of this work by the Maryland Commission, an aggregate of 1,644,304 hatched and planted.

During the year, the *avant courier* of those first deposited should appear in the bay and tributary rivers; but we cannot look for the appearance of any large number, even if the experiment of their introduction is thoroughly successful, before next year, or possibly the year after.

We have made the effort to stock the Maryland waters with this variety of Salmon on the very large scale shown, as we are inclined to believe that their introduction will prove successful, notwithstanding the fact that the Salmon family has been considered an inhabitant of extreme cold waters only. We selected the California variety, not only as of more rapid growth than the Eastern, (*salmo salar,*) but also from the fact that they frequented much warmer waters than their Atlantic cousins were ever known to inhabit.

The following information given by the California Commissioners is of great importance, and answers the oft repeated question: Will the Salmon be able to live in our warm waters?

"The statistics hereafter given of the temperature of the water through which the Sacramento and San Joaquin Salmon pass to reach their spawning grounds, show that they swim for hundreds of miles through the second hottest valley in the United States, during the hottest portion of the year, where the mean temperature of the air is 92° Farenheit, and of the water, 75°. These statistics have been obtained from the record kept by the Central Pacific Railroad Company, and are for the months of August and September of the years 1875, 1876 and 1877. They are of importance as showing that the Sacramento Salmon will enter

rivers for spawning purposes, where the water is so warm that the Eastern Salmon (*salmo salar*), if it were to meet it, would turn back to the ocean. They are also of importance as illustrating the probability that there are many streams on the Atlantic coast, from the Potomac to the Rio Grande, into which this fish could be successfully introduced."

That the Eastern Salmon can be acclimated, at least in the Susquehanna and Potomac, seems now to be possible. We have, from time to time, placed a few thousands of the Penobscot Salmon in the tributaries of these rivers, by way of experiment, and as they have been so successfully introduced in the Delaware, may be rewarded by like results in the tributaries of the Chesapeake.

There has, to some extent, existed a very erroneous opinion as to the value of the Salmon as a food fish, an impression, no doubt, caused by the glowing descriptions of the exciting contest with this king of fishes, given by enthusiastic anglers since the days of Isaac Walton. Their introduction into Maryland has met favor rather with the angler than the fisherman. But that the Salmon occupies a prominent place among the fishes which furnish largely a healthy food for mankind, and add materially to the wealth of any country producing them, is shown by the following statistics of the yield of two rivers alone.

"The following tables will show the numbers and weight of Salmon transported on the railroads and steamboats from the Sacramento and San Joaquin rivers to the cities of San Francisco and Stockton, from points on the river below the cities of Sacramento and Stockton, from November 1st, 1875, to August 1st, 1876, and from November 1st, 1876, to August 1st, 1877. They do not include the catch of the fisheries at Tehama or near the mouth of the Feather river, nor do they include the fish taken on the upper waters of the Sacramento and San Joaquin, nor the Salmon brought to market by fishermen in their own boats; therefore, to the totals should be added at least twenty-five per cent., to show an approximation of the actual catch:"

STATEMENT

"Of Salmon transported from the following stations on the Sacramento and San Joaquin rivers to San Francisco and Sacramento, from November 1st, 1875, to August 1st, 1876

FROM THE FOLLOWING STATIONS TO SAN FRANCISCO:

Collinsville, New York of Pacific, Rio Vista, Emmaton, Jersey Landing, Antioch, Benicia, Clarksburgh, Courtland, Martinez, Kentucky, Bradford, Sacramento, Vallejo, and Webbs.

127,843 loose Salmon, weighing	3,196,075 lbs.
2,433 boxes of Salmon, weighing	486,030 lbs.
3,118 sacks and baskets of Salmon, weighing	311,800 lbs.
158 barrels of cured Salmon, weighing	31,600 lbs.
512 barrels and boxes of smoked and dried Salmon, weighing	102,644 lbs.
Total	4,128,149 lbs.

FROM THE FOLLOWING STATIONS TO SACRAMENTO:

Courtland, Benecia, Rio Vista, Collinsville, Emmaton, and Clarksburgh.

1,116 loose Salmon, weighing	29,150 lbs.
106 baskets and sacks of Salmon, weighing	10,600 lbs.
53 barrels of Salmon, weighing	12,850 lbs.
414 boxes of Salmon, weighing	57,440 lbs.

FROM ANTIOCH TO STOCKTON.

70 loose Salmon, weighing	1,750 lbs.
46 boxes of Salmon, weighing	9,200 lbs.
Total weight of Salmon	4,249,139 lbs.

NUMBER OF STURGEON.

5,466 loose Sturgeon	274,375 lbs.

STATEMENT

Of Salmon transported from the following stations on the Sacramento and San Joaquin rivers to San Francisco and Sacramento, from November 1st, 1876, to August 1st, 1877.

From the following Stations to San Francisco:

Collinsville, New York of Pacific, Rio Vista, Emmaton, Jersey Landing, Antioch, Benicia, Clarksburgh, Courtland, Martinez, Kentucky, Bradford, Sacramento, Vallejo, and Webbs.

143,998 loose Salmon, weighing	3,599,950 lbs.
1,903 boxes of Salmon, weighing	384,300 lbs
3,454 sacks and baskets of Salmon, weighing	345,400 lbs
128 barrels of cured Salmon, weighing	25,600 lbs
653 barrels and boxes of smoked and dried Salmon, weighing	132,788 lbs.
8,542 boxes canned Salmon, weighing	546,688 lbs.
Total	5,034,726 lbs.

From the following Stations to Sacramento:

Courtland, Benicia, Rio Vista, Collinsville, Emmaton, and Clarksburgh.

1,511 loose Salmon, weighing	37,775 lbs.
208 baskets of Salmon, weighing	20,800 lbs.
414 boxes of Salmon, weighing	74,350 lbs.
47 barrels of Salmon, weighing	11,950 lbs.

From Antioch to Stockton.

106 loose Salmon, weighing	2,650 lbs.
63 boxes of Salmon, weighing	12,600 lbs.
Total weight of Salmon	5,194,851 lbs.

Number of Sturgeon.

5,913 loose Sturgeon, weighing	295,650 lbs."

"In our last report, after adding twenty-five per cent. to the statements of the catch which we obtained, we showed the total weight as transported from the same places, from November 1st, 1874, to August 1st, 1875, to be five million ninety eight thousand seven hundred and eighty-one pounds. Adding the same percentage to the totals in the above tables, and they show the catch from November 1st, 1875, to August 1st, 1876, to be five million three hundred and eleven thousand four hundred and twenty-three pounds;

and from November 1st, 1876, to August 1st, 1877, six million four hundred and ninety-three thousand five hundred and sixty-three pounds.

This shows a gain of more than a million of pounds in the legal catch over any year since the organization of the Commission, and may be ascribed to the fact that our waters are now beginning to feel the beneficial effects of the millions of Salmon hatched artificially and turned into the headwaters. We have no means of ascertaining the weight of fish taken out of season, but estimate that between August 1st and November 1st of this year, not less than two million pounds were taken in defiance of law."

Thus, it will be seen that the Salmon fisheries of California are of hardly less importance than our Shad and Herring fisheries.

The distribution of Brook Trout, in pursuance of the programme given in report of January, 1877, will be found in tabular form. In addition to these, about 10,000 Lake Herring and about 15,000 White Fish hatched from eggs gathered by Wm. H. Hines from Lake Erie for the Commission, were placed in the big pool on the Chesapeake and Ohio Canal.

We have secured 350,000 Brook Trout eggs, a large portion of which have been hatched and will be ready for distribution about the middle of January, and notice to this effect has been very generally published throughout the State.

It is gratifying to be able to state that the total cost of these fish will be about $2.55 per thousand. With the want of facilities for the storage of breeding fish, and the undeveloped resourses of the Commission, this compares very favorably with the estimated cost (15 s. per thousand,) of the production of Trout at the celebrated establishment at Huningen, under the careful and economic management of Mr. Haack.

SMELT-HATCHING OPERATIONS.

The efforts to propagate artificially the Smelt, *Osmerus mordax*, of the Raritan river, New Jersey, in 1876, when we procured the adult fish which were about to spawn, as they were taken from the river in the nets fished at New Brunswick, and transferred the fish to the Hatching House in Druid Hill Park, there took the eggs and milt from them, and treated the same in the apparatus there in use, having resulted unsuccessfully, I determined to repeat the experiment, establishing headquarters at New Brunswick, and taking the eggs from the ripe fish as they were landed from the seines.

Having visited New Brunswick with this view, and made the necessary arrangements, I transferred the apparatus and improvised a temporary Hatching House. On the 3d of March, having secured the services of Mr. H. J. Rice, Fellow in Natural History of the Johns Hopkins University, through the kindness of President Gilman, the able head of the University, I placed under his direction Wm. Hamlen, one of the employees of the Commission, who had been carefully trained by me in taking the spawn of several other varieties of fish.

The record of the operations at New Brunswick will be found in subsequent table; the detailed account of the operations, and history of the gradual development of the eggs, will be found in Mr. Rice's able report appended, which is illustrated by accurate and well executed microscopic drawings made during his sojourn at New Brunswick. As Mr. Rice gives a full and interesting account of operations and natural history observations, I think it unnecessary to go into more full details.

On the 20th of April I reached Baltimore with several cans of young Smelt—the result of these experimental operations. It was impossible to count them, or to estimate with any certainty the number of fish contained in these cans, as

they were very much smaller than any we had been accustomed to handle; but I got several parties, who had been in the habit of carrying Shad, to estimate them, and the estimates ranged from a half to three-quarters of a million. To be within bounds, I have recorded them 400,000—the number of young Smelt planted in the waters of Maryland. About one-half of these were deposited in the head-waters of the Severn, on the 21st April. About two-thirds of the remaining 200,000 were placed in the head-waters of the Wye. The others were left in charge of Hon. Edw. Lloyd, Senator from Talbot, who kindly transferred them to the head-waters of the Saint Michael.

In addition to these young fish, some few adults were deposited in the Wicomico river at Salisbury, under the direction of the Hon. Thomas Humphries, who represents Wicomico county in the Senate.

If the Smelt can be successfully introduced into the waters of the Chesapeake bay, they will be a very valuable acquisition; and that they can easily be influenced by artificial means has been shown in Massachusetts. (See extract of letter from Hon. Theodore Lyman on page 2.)

These fish being very small, and liable to be preyed upon by the larger fishes inhabiting the bay and the neighboring ocean, it is necessary that they appear in very great numbers for their presence to be felt.

By reference to Mr. Rice's report, page 48, it will be seen that they are a very prolific fish, and once established, the supply can be readily kept up.

SHAD-HATCHING.

Having been unable to secure ripe fish in sufficient quantities at any one point on the smaller rivers of the State, the Shad having become scarce in these streams, I determined to concentrate operations at some central point where a great many large fisheries could be visited, and the fish

taken by them, overhauled. The experiences of the spring of '76 convinced me that a much larger number of ripe fish, and consequently a much larger number of eggs, could be procured in this manner. I therefore communicated with the Commissioners of Fisheries for Virginia, and proposed that they should join with me in the work on the Potomac; this, however, they declined to do, from want of funds. The appropriation at my command was not sufficient for me to equip two central hatching stations, and I was, therefore, compelled to postpone operations on the Potomac. I deemed it more advisable to concentrate the work at the Head of the Bay, a more central locality; and a much larger number of citizens of the State would be benefited by the return of the fish deposited in waters over which the State had entire control, and on which bordered all the tide-water counties, except Prince George, Charles and Worcester.

The interest which Prince George, Charles and St. Mary's counties have in the fish of the Potomac is so large, and the yield of the fisheries of this river is so important to the State, that the most strenuous efforts should be made to restore them.

It is hoped that the General Assemblies of the two States will make the necessary provisions for their restoration before the next fishing season, and that the States will join in the work of artificial propagation and mutual protection, the beneficial results of which will be shared by their citizens in common.

Several hundred thousand of young Shad were transferred by rail from the station at the head of the bay and deposited in the Potomac, as will be seen by table of distribution.

Hereafter, with the success which must follow our increased facilities and experiences, very much larger numbers can be thus transferred from the bay to this important river, even if we are not provided with means to bear the whole expense of a separate station, or in the event that the Virginia Commissioners do not co-operate with us.

Having decided, therefore, to concentrate all our energies and means at the head of the bay, in the neighborhood of Havre de Grace, I watched the condition of the water and the season closely. The weather kept unusally cold during April, and the development of the ova in the ovaries was very much retarded ; it was not until the 25th of April that I found, on visiting the battery of Capt. Cole, which was located just above the railroad bridge, at the lower end of Watson's Island, some Shad, with spawn considerably advanced, and the milt ripe in the male fish.

I found, on this occasion, quite a number of ripe Herring, and took some two or three hundred thousand eggs, which I placed in the hatching apparatus on the steamer ; but being compelled to return to Baltimore to complete the equipment for the Shad-hatching, the eggs could not be left in the hatching apparatus until matured ; the experiment made with them, however, although unsuccessful, was important as the first step towards the work of the future.

On the 30th of April, having secured from the Harbor Board of Baltimore the use of three large deck scows, and having erected machinery and apparatus, hereafter described, I had them towed to the head of Spesutie Island, and a few days subsequently to Havre de Grace.

Havre de Grace was chosen at this time, not only as being a very central location, but as a point from which we could get the remaining material needed for the completion of the works on the scows. It was not until the 8th of May that any ripe spawn was found. At this date, in the neighborhood of Havre de Grace, there were in operation four batteries and one shore fishery above the railroad bridge ; below the bridge, on the Susquehanna flats, three more batteries; on the western side of the bay, the Old Bay Fishery and a small fishery at the mouth of Swan creek, and the upper and lower fisheries on Spesutie Island.

On the eastern side of the bay, the Cecil county side, the large fisheries of Fletcher Wilson, Wm. Wilson, Caruthers

& England, Russell, and two at Carpenter's Point, owned by Mr. Washington Barnes.

The total length of the seines of these eighteen fisheries is about 26,350 yards, and the ripe fish caught by this immense aggregation of seine can all be utilised for furnishing spawn for a central hatching station, by means of proper organization and equipment.

All of these fisheries were visited from time to time. It will be seen, by reference to the table showing the temperature and the details of the operations conducted, that the air and water continued quite cold, for this season, until about the 12th of May, when there was a constant southerly wind and increase in the temperature; on the night of the 14th, having gotten the apparatus in working order, I visited, for the first time, the fisheries on Spesutie Island and the eastern shore of the bay. On this one night I took, at the smallest calculation, 1,250,000 eggs. These were kept, during the night, in the tanks on the steamer, and the next morning taken to Havre de Grace.

The yield of spawn was so much greater from the fisheries on the Cecil side, that I determined to move the apparatus to Carrot cove, on the North East river; consequently, on the next day, I had the scows moved round to this more convenient locality, and this continued to be our central station until the 27th, when I deemed it advisable to move the scows to Spesutie narrows.

The water at the mouth of the North East and in Carrot cove, being shallow, was more easily influenced by the temperature than the deeper and more rapidly flowing water at Spesutie narrows. About this time, the weather became exceedingly hot, and the temperature rose rapidly to 78°. Spesutie narrows was also a more central station for the gill-nets, and as the season was about closing for the seine-haulers, we had to look for our supply of ripe fish to the gill-nets alone.

From this station, on the 1st of June, I commenced the distribution of fish, by means of the steamer, to the several important rivers of the Eastern Shore. On the 1st of June, I deposited 126,000 in the Bohemia, near the bridge across that stream; on the same day, 150,000 in the Elk, and 285,000 in the Sassafras. I am indebted to Hon. Wm. M. Knight for assistance and guidance in this transfer, as he accompanied me on the trip from the Bohemia to the Sassafras. On my return to the hatching station, I took a large number to the Choptank river, which was reached on the morning of the 5th; the fish in good condition. After stopping a few hours at Cambridge, for the purpose of securing a pilot, I proceeded up the river, and deposited 510,000 young fish in the Choptank, just below the town of Denton.

On the 11th of June, having secured from the hatching station 300,000 more fish, I proceeded down the bay to Crisfield, which place I reached on the morning of the 12th, in time to ship them by the mid-day freight train to Salisbury. Those intended for the Wicomico, 100,000 in number, were placed in that river at Salisbury, under the supervision of the Hon. Thos. Humphreys, Senator from Wicomico; 100,000 were also shipped to the Pocomoke, and deposited in that stream at the point at which the Wicomico and Pocomoke Railroad crosses the stream, and 100,000 were placed in the Nanticoke at Seaford.

Prof. Baird, at my request, undertook the distribution of the fish by rail to those localities which could not be reached by the steamer. Accordingly, he caused to be transferred to the Potomac 250,000; of these, 150,000 were deposited at Piedmont, and the rest below Washington; 160,000 were put in the Patuxent river, where the railroad crosses it, and 50,000 in the Gunpowder river, near Cockeysville. This completed the distribution of Shad in Maryland waters, making in all 7,419,300.

An interesting account of the operations at the head of the bay, and the development of the ova of the Shad, will

be found in Mr. Rice's report to me of his observations upon the development of the Shad, on page 95, *et seq.*

The Frontispiece of this report is a representation of the apparatus referred to on page 7, which was erected on the steamer Lookout.

This apparatus consists of tank "B," which is placed on a tank "C," to give it an elevation sufficient to supply the several inverted cones "A," with a constant circulation of water; this is supplied by means of a steam pump, located below the deck and provided with steam from the boiler, which also supplies the main engine. The water is drawn direct from overboard through the sea-cock, and is conducted from tank "B" through filters "a," and rubber tubes attached, to the *apices* of the inverted cones, and overflows at "f." The waste water is conducted through pipes "c" into waste-tank "D," and thence carried overboard through pipe "E." The distributing-tank "B" is provided with a tube "g," which serves a double purpose—an outlet for the air, and, when necessary, an overflow for the surplus water. When it is necessary to furnish a stronger flow by direct action of the pump, the rubber tubes can be transferred from the filters "a" to pipes "d," and the valve at "b" shut off, so as to force the water directly into the inverted cones. The pump is furnished with two suction orifices, and when running in salt water, the outlet "E" is so arranged that by turning it into the hatch shown in the drawing, and attaching it to the suction pump, the water, after having passed through the hatching cones "A," is repumped into tank "B," and a circulation of the same water kept up.

The large tank "C," which is used for a support to tank B, is also supplied with fresh water, to replace any waste from splashing, evaporation, &c. It will be seen that by means of this apparatus, hatching operations can be conducted on board the steamer, whether in motion or lying at anchor, either in fresh water, when the supply is taken from overboard, or in salt water, when the circulation and renewal

of the water is kept up by the arrangement referred to. The thorough efficiency of this apparatus was demonstrated last spring, as in the five tanks shown in the drawing, over a million of eggs were easily kept during twelve or fifteen hours, until the central hatching apparatus was reached; and, in some cases, several hundred thousand eggs were kept in these tanks from the time they were taken until completely developed and the fish distributed.

These vessels were also very efficient for transferring the young fish from one portion of the State to another. In this constant circulation of the water, the fish can be transferred much better than in the ordinary transfer cans, such as shown in the illustration. The other form of apparatus which was used at the central station, is fully described in the specifications of the patent, as follows:

THOMAS BARKER FERGUSON'S

IMPROVED FISH HATCHING APPARATUS.

This invention relates to methods and devices for hatching spawn of fishes, and has for its object, to hatch such spawn in still waters where the current will not impart sufficient motion to the eggs, or furnish them with a sufficient change of water; and also in waters exposed to storms. To this end, the nature of the invention consists in a series of vessels in which the spawn is placed, combined with a mechanism that will impart sufficient motion to the vessels to create the necessary current and change of water. It also consists in the construction of the spawn vessels, and in the construction and combination of parts, as will be hereinafter more fully set forth.

The annexed drawings, to which reference is made, fully illustrate my invention. *A A* represent a series of cylindrical vessels made of sheet metal or other suitable material, and of any suitable dimensions, and which may be made slightly tapering, or not, as may be deemed most advantageous

Each vessel *A* is provided at its lower end with a bottom *B* of wire cloth or similar material, which is held in place by means of a metal band *C* as shown. Under certain circumstances, the top of the vessel may be provided with a similar wire cloth *B'*, held in place by a metal band *C'*; this latter band being placed within the vessel, while the bottom band *C* surrounds the lower end of the vessel on the outside.

By this means the wire cloths *B* and *B'* can be easily removed when required, and as easily replaced.

The vessels A are provided at the top with suitable handles a a, and are suspended by means of wires, cords or chains b b, from the devices hereinafter described.

E represents the hull of a boat, scow or other vessel, or pier, on each side of which is arranged a series of levers D D, pivoted on such boat or vessel, and their outer ends projecting a suitable distance beyond the side of the same. These levers D on each side of the vessel may be arranged singly or in pairs. If in the latter way, the two levers forming a pair have a rod d passing through their outer ends, and a series of vessels A are suspended from said rod by means of the cords or chains b.

The vessels A thus hang outside of the boat or vessel in the water in such a manner that, when the lowest, they will only be about two-thirds under water. The inner ends of the corresponding levers on the two sides of the boat may be connected together as shown, or in any other suitable manner, or they may be left entirely disconnected if so desired. These levers are operated by a series of eccentrics I I, set at varying angles upon a continuously rotating shaft G, connected to, and rotating by a steam engine, or other suitable motive power.

The levers D may be mounted above the deck of the vessel, or they may be arranged below the deck, and project through the sides of the vessel; and the shaft, with the eccentrics, arranged to correspond with the location of the levers. In either case, these eccentrics should be of such form that a slow motion upward would be secured for the vessels A, while they should move more rapid, though gradually, downward.

By this means a current is created, even in still waters, sufficient to keep the eggs placed in the vessels A in motion, and change the water through the wire cloths in the bottoms of the vessels.

When the boat or vessel is placed in water having a sufficient current, no movement of the levers D is necessary; and in such case, each vessel A is held in an inclined position by means of a side chain or rope e, so as to allow the current to pass through the vessel. In such case, as well as in storms the tops B should be put on the vessels A to protect the spawn.

The vessels A being cylindrical in form, present no angles or corners in which sediment, dirt or matter deleterious to the life and development of the spawn can collect, and they are easily kept clean. Being made of sheet metal or other metallic substance, it prevents the development of injurious fungi and conferva. Another advantage of the cylindrical form of the vessels is, that it requires less force in its movement in the water than a box having angles or corners.

By this invention the spawn of fishes may be hatched in still waters, currents, and waters exposed to storms.

Having thus described my invention, what I claim as new, and desire to secure by letters-patent, is—

1st. In the hatching of fish spawn: the method of producing change of water in the vessels containing the spawn, and currents for moving the

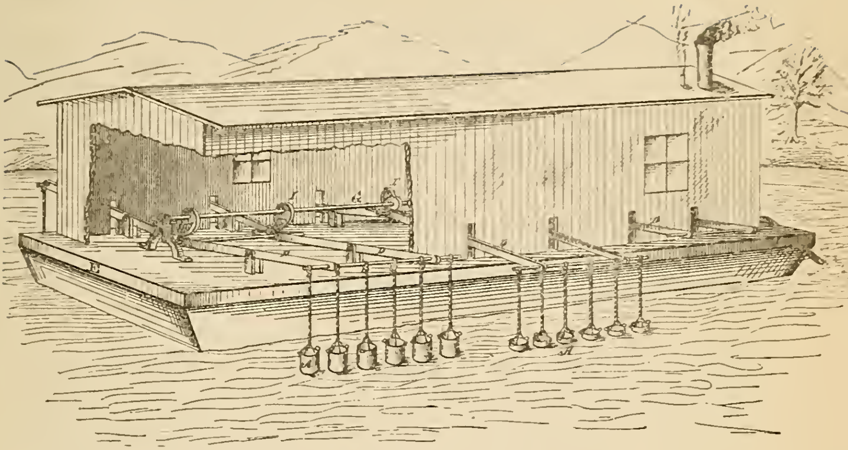


Fig. 2.

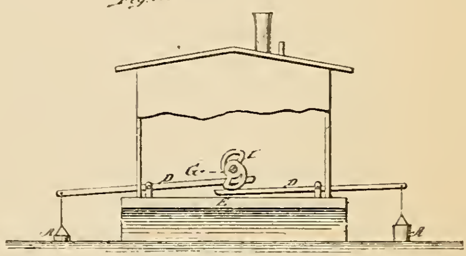


Fig. 3.

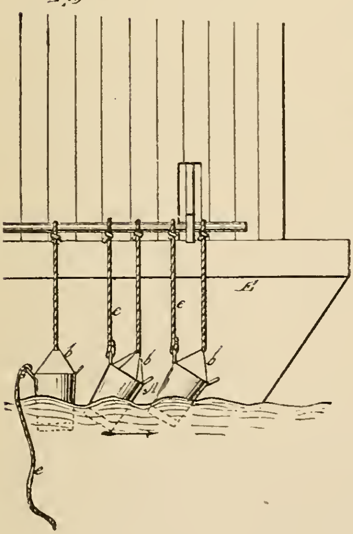
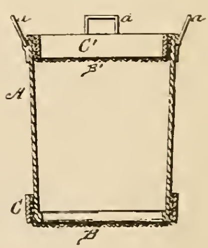


Fig. 4.



eggs, which consists in reciprocating the boxes or vessels in the water, substantially as herein set forth.

2d. One or more series of vessels for containing spawn, in combination with a mechanism for moving the same up and down in the water, substantially as and for the purposes herein set forth.

3d. The combination of the cylindrical vessel *A*, wire cloths *B B'*, and fastening bands *C C'*, substantially as, and for the purposes herein set forth.

4th. As a means for the hatching of fish spawn, the combination of a portable scow or other vessel with a series of vessels *A*, suspended from pivoted levers *D*, which are operated by a series of eccentrics *I*, set at varying angles on a continuously rotating shaft *G*, substantially as set forth.

The period in which Shad-hatching operations can be successfully carried on in Maryland waters, is limited by the conditions and temperature of the water, to about six weeks, extending from the last week in April, the time when the first ripe fish are found, until the 10th of June, when the catching of Shad is prohibited by law, and fishing ceases. The necessity for extending the period in which the gathering of spawn, and the development of the same, can be conducted, caused me to investigate the state and conditions of the fisheries further south, believing that by taking advantage of the earlier run of fish into the rivers more southern than those flowing into the Chesapeake bay, active operations in the field could be commenced some five or six weeks earlier, and a very much larger number of young fish procured for stocking the streams of the State.

With this view, I communicated with the Commissioners of North Carolina and Virginia, and they expressed their willingness and desire to co-operate in the work at points within their States. Having been informed by Dr. Wm. R. Capehart, the owner and operator of two extensive fisheries on the Albemarle sound, that spawning fish could be had in large numbers in the neighborhood of his fisheries during the fishing season, which commences about the 1st of March—as Dr. Capehart's intelligent observations could be relied on—I deemed it of sufficient importance to the future of our

fisheries to make as thorough examination of Albemarle sound and its tributaries, as possible to be made during the winter months, when no fishing operations are conducted.

Accordingly, by appointment, I met Col. L. L. Polk, Commissioner of Agriculture, also having charge of the Department of Fish Culture of North Carolina, and Dr. Wm. R. Capehart, and together we visited the several fisheries on the sound, as well as those on the Chowan and Roanoke rivers. On investigation, we found the most favorable circumstance surrounding these great fisheries; the accompanying map will show the location of the fisheries, and the lengths of seines used.

Almost all of the fisheries laid down on the map are operated by the owners of the adjacent farms, who are men of intelligence and culture, of enlarged and liberal views, and we are assured of the hearty co-operation of the entire community of fishermen.

The Albemarle sound, 65 miles in length, and from 5 to 15 miles in width, receives from its tributaries, the Roanoke and Chowan rivers, the entire water-shed of the northern and eastern portion of North Carolina, and the southern portion of Virginia, east of the divide in Montgomery, Floyd and Carroll counties, besides the contributions of fresh water from the shorter eastern rivers of North Carolina, flowing through Bertie, Perquimans, Pasquotank, Carroll, Tyroll and Washington counties.

This immense supply of fresh water is spread out over the comparatively shallow sound, which affords admirable spawning beds for Shad, Herring and Rock. The brackish water does not find its way, even in the dryer months of summer, higher than the mouth of the Pasquotank, for the communication with the salt water of the ocean is limited to Oregon, New, Loggerhead, Hatteras and Ocracoke inlets, all narrow and comparatively shallow.

The salt water entering these inlets to replace the fresh water discharged from the sound, must pass through the

channel between Roanoke island and the main land, which is about 2¾ miles across, with an average depth of about nine feet. During the spring months, the period of the run of Shad, Herring and Rock in seeking their spawning beds, the Albemarle sound is entirely fresh, and offers to them the most suitable localities for spawning.

It will be seen by reference to the accompanying map, that most of the large seines which yield even in the depleted condition of the fisheries 500,000 Shad and 45,000,000 Herring, and 300,000 lbs. of Rock (*Roccus lineatus*), are located within 16 miles of the mouth of the Chowan river.

I have pointed out to Prof. Spencer F. Baird, U. S. Commissioner of Fisheries, the great advantages offered by this locality for procuring young Shad for distribution throughout the United States; and it is now proposed that a joint work should be conducted by the U. S. Commissioner, and the Commissioners of North Carolina, Virginia and Maryland, at this point.

Should our arrangements be perfected, I am confident that immense numbers of Shad can be procured for deposit in the streams of Maryland, before the hatching operations can commence within our own limits. They can be transported with little cost by means of the steamer "Lookout," through the Albemarle and Chesapeake canal and the lower bay to Crisfield; thence by rail to the rivers of the Eastern Shore. By thoroughly stocking these rivers with this earlier supply of young fish, it would leave the results of our operations later in the season, for deposit in the Potomac, in the Susquehanna, in the Gunpowder, in the Patuxent, and in the other rivers of the north-western portion of the State.

As the Albemarle sound has long been celebrated for the immense number and size of its Rock fish, I hope and believe that we will there be able to find ripe Rock. I have anxiously searched for spawning Rock during the four years that I have conducted the Shad culture in Maryland.

I beg leave here to express my appreciatian of the kindness shown by Dr. Capehart, and the intelligent and public spirited owners of the fisheries of Albemarle sound, and also to Col. Marshall Parks, the President of the Albemarle and Chesapeake canal, who generously tendered me the use of the canal free of tolls.

BLACK BASS.

The general prejudice which has prevailed against the introduction of the Black Bass into our Shad and Herring rivers, has deterred me from stocking such rivers with this fish, although I do not join in this prejudice; but on the contrary, believe they would be valuable acquisitions, especially to the dark water rivers of the Eastern Shore, which have not mountain sources, and for this reason are not suitable for the more valuable Salmon.

While this prejudice against the Bass has prevented a general distribution of them to the Shad rivers, the want of means has prevented a distribution to private ponds, as the appropriation has not been sufficient to warrant work, except for the restoration of the public waters, where the greatest amount possible could be accomplished for the general good.

The very numerous applications which have been received, especially from those persons having large ponds in the comparatively flat regions of the State, have caused me to make arrangements for a large supply of both the small-mouth Bass, (*Micropterus salmoides*), and the large-mouth variety, (*M. nigricans*), which I hope to distribute before their spawning season in the spring.

The small-mouth Bass is better adapted to the clearer, colder and more rapid flowing waters, and the large-mouth Bass for ponds and tidal rivers; the latter is perhaps the most valuable, as being of more rapid growth, and attaining a greater size.

A gratuitous distribution of Bass, as that proposed of Brook Trout, will supply those localities which are not suited for the Trout.

CARP.

Three importations of European Carp, made under the auspices of Prof. Baird, U. S. Commissioner, have hitherto been reported. Those brought out by Dr. Hessel, though of the best variety, were in insufficient numbers ; and those brought over by Mr. Welsher having proved to be an inferior variety of Carp, Prof. Baird determined to attempt another importation, and Dr. Hessel accordingly returned to Europe, and in May last reached New York with his cargo, and from thence brought the fish to Baltimore, arriving on the night of 26th of May, with 79 King Tench, (*Cyprinus tinca*), 227 Naked Carp, (*Cyprinus nudus*), 118 Common Carp, (*Cyprinus carpio*). These, Dr. Hessel, who has had great experience in Carp raising, reports to be from the best ponds, and of the choicest varieties known in Europe.

As it is desirable to keep the different varieties separate, and as more storage room was needed in Druid Hill Park, application was made to the City Council for sufficient means to construct additional ponds. In response to this application, one thousand dollars was appropriated for this purpose; and under the supervision of the Park Commissioners, three large and well-designed ponds are now in progress of construction. When these are completed, we will have five large ponds in which to keep the breeding fish, besides the small ponds in which it is designed to mature the eggs taken artificially from the parent fish.

For the purpose of transferring the fish across the ocean, I designed and had constructed an apparatus in which it was hoped that this transfer would be successfully made. It was intended that the fish should be brought direct from Bremen to Baltimore, in one of the Baltimore steamers, as much greater space could be devoted to the reception of the apparatus on this line than on steamers entering New York, and the most liberal accommodations were offered by the agents of the North German Lloyd at this port. This apparatus was transported to Europe by the company free of

charge. It consisted of two tanks, one of these to be elevated above the tanks in which the fish were to be placed, and located under one of the skylights. This tank supplied the water to the vessels, which consisted of deep tubs swung in gimbals, so as to keep them horizontal, notwithstanding the motion of the vessel.

The water was transferred from the reservoir through rubber tubes, to which were attached a contrivance for forcing air to the bottom of the water in the fish tanks. As this was effected by the passage of the water through the tubes, it worked automatically. In this way the fish were supplied with the necessary oxygen.

The overflow was conducted into a tank similar to and of the same capacity as that above, and thence transferred by means of a force pump to the distributing tank. In this manner, a constant change and circulation of water could be kept up without annoyance to the fish, and the water easily saturated with atmosphere.

I understand that Dr. Hessel could not get sufficient accommodations on the New York steamer in which he took passage, and therefore did not use the apparatus.

The fish were a good deal bruised on the passage, and arrived in bad condition; several of them died subsequent to their arrival at Druid Hill Park. With the increased facilities for caring for the fish in separate ponds, it is hoped that in a few years, the young from these several importations will be sufficiently numerous to stock many of the ponds to which these fish will be a valuable acquisition.

Especial acknowledgment is due to the Commissioners of Public Parks, who have aided, with the means at their disposal, the work of construction of ponds, &c., when the specific appropriations have been inadequate; and to the Water Board of Baltimore, for their liberality in supplying water during the winter months, when a much larger supply than that afforded by the spring is necessary for carrying on the extensive operations which are conducted at the Hatching House.

BUFFALO FISH.

The introduction of the Buffalo Fish is the unfulfilled promise made by the Commission, but I trust that this will be accomplished during the coming spring, as I believe that this fish will be a very valuable acquisition to our fresh waters, especially for the more stagnant ponds, which will not support any of the game fishes, and those ponds too limited in capacity to supply natural food for a large number of fish.

The Buffalo Fish is readily domesticated, and can be fed on much of the refuse from a farm. In this opinion I am sustained by Dr. E. Sterling, who is a well known and competent icthyologist. Dr. Sterling writes me: "I see that you are in favor of introducing the Lake Mullet, or Buffalo Sucker, (*Catostomus aureolus*—Lesseur,) as it is commonly called, and I think you are right. It is a rapid grower, and attains here, in three or four years, the weight of 7 to 9 lbs. It domesticates as readily as the European Carp, will feed off the garbage of the kitchen, and is by far the best table fish of the two" * * * * "Some years ago a Hungarian in my father's employ planted a number of small Mullet in a narrow deep pond of four acres. The stream supplying was of a surface character, so much so that for weeks in the hot weather no water was supplied by it to the pond; yet, the fish flourished all the same. They were fed on whatever came handy from the house, grew rapidly, and became so tame as to approach at the sight of any one coming near, especially to feed them. At the end of the third season, many had become quite large, weighing over five pounds, and during the cold weather were considered delicious food." Thus, it will be seen that by the transfer of

this fish from the western waters a comparatively good food-fish can be secured for our ponds, until the Carp become numerous enough for general distribution.

LIST OF FISHES.

Tho investigations of the past year have enabled us to add 12 species to the 190 enumerated in reports hitherto published, making in all 202 species known to Maryland waters. No doubt, future collections will furnish yet additional specimens to our already large representation.

The descriptive list of these additional fishes, with observations on the fall advent of the Blue Fish, and their forerunner, the Ale-wife, (*B. menhaden*,) made by Mr. Otto Lugger, the energetic custodian of the Museum of the Maryland Academy of Sciences, will be found on pages 111, and following.

In the identification of these species, we are indebted to Prof. Spencer F. Baird, Prof. Theo. Gill, Prof. G. Brown Goode and Dr. T. H. Bean, of the Smithsonian Institution, and also to Prof. P. R. Uhler, President of the Maryland Academy of Sciences, for valuable assistance.

PROTECTION.

The history of the work of the Commission for the past four years, does in itself embrace the suggestions for the protection and propagation of the food-fishes in the waters of the State, which section 4, chapter 27, Laws of 1876, makes our duty to report, but as a reference to the modes of capturing, as now resorted to in our waters, may in some measure be a guide to the more effectual means of protecting our fish

from undue destruction by them, it may be well to review the means employed; they are—

1st. Angling, or the capture by the use of hook and line.

2d. Spearing, either during the day when the fish are found in shallow water, or by the use of torch lights along the shore at night.

3d. Fish baskets or fish weirs.

4th. Haul seines.

5th. Gill nets.

6th. Fyke nets.

7th. Pound nets.

8th Purse seines.

There can never be any material injury resulting from the first of these methods, as in angling, fish are taken while in pursuit of food, and as this is limited to certain times of the day or periods of the year, even if an unlimited number were engaged in capturing fish with the line, there could not be that steady drain that results from the other methods; but for the better protection of fish, especially those inhabiting the upper waters beyond the influence of tide, the breeding season of each variety should be set aside, during which they should not be captured even by angling.

Not only does their preservation and increase necessitate this protection, but as the flesh of spawning fish is unwholesome and unfit for food, the protection of health also demands it as a sanitary measure.

The 2d method, spearing, is not to any very great extent resorted to within our State, but, as it is most efficient when the fish are on their spawning beds, and more vigilant in guarding their nests than in providing for their safety, and as it is resorted to chiefly at night, when there is little probability of well regulating the use of the spear, under the supervision of the law, this method should be prohibited altogether.

These two methods of capture, are, however, simply resorted to for supplying a home consumption and local demand.

Except with some fishes which do not frequent our waters, they are rarely resorted to as a means for supplying fish for an extensive market or for export.

Fish baskets or weirs, as described in previous reports, are also used for meeting a home demand and furnishing a local supply, but as the injury they do to the streams in which they are operated, and their capacity for destruction is so much greater than the amount of good produced, their use should be prohibited by law.

The haul seine is perhaps the most ancient and extensively resorted to method for capturing fish, not only to furnish a comfort for home, but for supplying the general market.

There is a considerable amount of capital invested in haul seines and their necessary equipments, and a very large yearly yield of healthy food is derived from the seine fisheries of our State.

As there are large interests involved, and as an immense food supply is furnished for home consumption and export, by the haul seine, the advantages and disadvantages of this method should be carefully weighed, so as to avoid any unjust discrimination against, or undue license to its employment.

The haul seine, the gill net, stationary or floating, and the pound net, are each operated by separate, distinct and antagonistic interests. Each class has much to say in favor of its special mode of capture, and a very great deal against that of every other.

Those operating the haul seine, while acknowledging that they capture every thing within their "lay out," and that all the fish are destroyed that are brought to shore, yet argue, and with effect, that they are only operated periodically, and that the fish are undisturbed for several hours during the day, and an opportunity offered for many to reach their spawning beds.

The largest seines and the greatest number of men are employed during the spring, at the time of the run of Shad

and Herring, and with many of the larger ones not more than two or three hauls are made during the twenty-four hours, which gives the fish considerable opportunity to pass and reach their spawning beds.

The haul seines are not operated until the close of the spawning season, but allow the fish which have escaped, a considerable time to spawn undisturbed. Again, the young Shad and Herring are not in the water at the time that the seines are used for the capture of the adults, and they do not materially injure the young of these fish—they are, however, very injurious to the partially grown of other varieties. The lead line dragged over the bottom, almost constantly, no doubt destroys great quantities of spawn, but more especially that of other varieties than the Shad.

The gill net is very extensively used in Maryland, principally for the capture of Shad, although, of late years, Herring gill nets are becoming very generally used, both on the Potomac and upper bay.

Those operating the gill nets, argue in favor of this mode, that the meshes are so large, that none but the large marketable fish are captured, while the small fish pass through freely, and that in many localities they can only operate these nets at night and at certain stages of the tide, giving the fish good opportunity for reaching their spawning beds; however, in some localities where the water is not clear enough to enable the fish to avoid the nets during the day, they are kept in the water almost constantly, and have no doubt contributed very materially to turn back the fish, and prevent them from reaching their natural spawning beds in the upper waters.

Very many of the smaller fish of the Shad and Herring, which effect their escape from the gill nets, are taken in seines higher up the rivers I have found the spawn dead in almost all those fish that I have examined, thus showing that although they themselves may escape, they will not reproduce after being bruised by their struggle through the meshes.

The fyke net is not very extensively used in Maryland waters, but the principal objection to its use is, that it is one of that character of apparatus which can be constantly operated.

The net with its leaders, often occupying the entire width of the smaller streams, prevents the passage up or down of any fish too large to pass through its meshes. This, with the pound net and other stationary apparatus for catching fish, should only be permitted under restrictions which would cause its being taken from the water periodically during the migrations of the fish.

Those operating the pound nets claim the same advantages that the gillers do for their method, that they capture only the marketable fish, as the meshes used are too large for all but the fish of marketable size to pass through them; but these nets with their leaders being stationary and almost all the time in the water, prevent very many fish from ascending the bay and streams, and very many marketable fish which are not taken are thereby turned back and prevented from reaching proper localities in which to reproduce.

It has been found, in those rivers from which the fish have been debarred from ascending and reaching proper spawning grounds, that in a very few years they have entirely disappeared, even from the mouths of the rivers, so that the final disappearance of fish from a river is not only dependent upon the destruction of those captured, but also upon the failure of those escaping to reach their accustomed spawning beds.

As much can be said of the advantages and disadvantages of each of these methods of capture, it would appear most practicable and the wisest policy to permit the use of each kind of net, but under proper restrictions.

A periodical close time during the run of fish, and a total cessation of their capture at certain times, so as to leave them entirely undisturbed on their spawning beds, are necessary measures to arrest the alarming decrease in our fish yield.

The greatest injury, however, which is done to our waters of the Chesapeake bay and tributaries, without any compensation whatsoever to our citizens, is the capture of fish throughout the year by means of haul seines and purse nets, operated by parties who come into the bay with vessels well supplied with ice, capture the fish and take them to other markets.

Immense numbers of fish are taken by this class, citizens of other States, every year, and carried to Philadelphia and New York, and there is not the remotest, even temporary, benefit that the State derives from the depletion of her waters, as the fish are taken by non-residents who seldom have any communication with the shore, except, perhaps, to land their nets in defiance of the wishes of the proprietors of the land.

CONCLUSION.

In conclusion, I would repeat, as the result of the more close observation of the past two years, the causes to which I attribute the decrease in the fish yield of our waters, and the remedies suggested therefor, namely—

"1st. Excessive fishing.

2d. The cutting off of the migratory fishes from their spawning beds.

3d. The disturbing of the breeding fish on their spawning beds.

4th. The destruction of spawn, by washings from cultivated fields, and natural enemies.

5th. The destruction of young fish, by improper means and modes of capture.

The remedies are—

1st. Artificial propagation to supply the excessive drain caused by increased population, and improved means of capture.

2d. By prohibiting all fishing with nets, seines or fixed apparatus for thirty-six hours in each week, during the migrations of anadromus fishes, so as to give a sufficient

number of breeding fish an opportunity of reaching their spawning grounds, (this is universally believed to be the most important step towards the preservation of our best food fishes.)

3d. By protecting the fish on their spawning beds; that is, by prohibiting their capture as their spawning seasons approach, (the habits of each species must determine the period in which it should be protected.)

4th. By the apparatus of fish culture to protect the eggs and young fish from the causes of loss.

5th. By regulating the size of the meshes of nets and seines, and by prohibiting the erection or use of "fish-traps" or "fish-baskets," (we cannot too strongly urge the entire abolition of "fish-traps.")

We would recommend that a small tax be levied on seines, nets and fixed apparatus used to capture fish, and that the tax be in proportion to their capacity of destroying fish.

We would also recommend, in order to better regulate the fishing, that all nets, seines and fixed apparatuses, be licensed, and that "Fish Wardens" be provided, whose duties will be to see the laws enforced in the river districts, and that provisions be made to ensure the observance of the laws in the bay and navigable rivers."

We beg to express the thanks of the Commission to Mr. J. Alexander Shriver, Vice-President of the New York and Baltimore Transportation Line, for 4 Root's steam engines, which will be used for rotating the shaft of the Shad-hatching apparatus described on page 25.

The work of the Commission has been much facilitated by the continued co-operation of the several lines of transportation in the State, and I beg again to acknowledge our obligations to the several presidents and agents of these routes, who have been specially enumerated in my previous reports, as they have continued their assistance in the transportation of live fish, &c.

Respectfully submitted,

T. B. Ferguson, *Commissioner.*

OBSERVATIONS

UPON THE

Hatching, Development and Variation of the

RARITAN RIVER SMELT, (Osmerus eperlanus).

H. J. RICE, B. Sc. Cornell,

Fellow in Nat. Hist., Johns Hopkins Univ.

Baltimore, December 1st, 1877.

Mr. T. B. Ferguson,

Commissioner of Fisheries State of Maryland.

Sir:—Having been desired by you last March to take charge of, and report upon the methods of hatching the spawn of the Smelt of the Raritan river, N. J., upon which you were about to begin operations, and which was a new field of labor for the Commission, I hereby have the honor to report to you such observations as I was able to make while engaged in embryological work at the headquarters of the Commission.

The field of operations was at the city of New Brunswick, situated about 8 miles from the mouth of the Raritan river, where it empties into the Raritan bay. The Smelt come up the Raritan river from the bay in great schools during the winter and spring months, for the purpose of depositing their spawn; and during this time they are often caught in immense quantities. About five miles above the city of New Brunswick there is a dam which blocks the river, and which the Smelt cannot surmount. They become, thus as it were, shut into a bag, with the blind end near the city. The fishing grounds,

however, may be said to extend from the old wooden city bridge—which connects the city with the country lying N. E. of the river—down the river for two or more miles; very little, if any fishing being done above the bridge, on account partially of the little depth of water, partially because the Smelt appear to pass down the river again, after being impeded in their onward course by the dam The Smelt are caught entirely with seines, which include in their sweep, nearly the entire breadth of the river, averaging about 30 rods.

The seines vary from 30 to 60 fathoms in length, 180 to 360 feet, and are about 15 feet in breadth, with meshes one-half inch square. The time of working the seines depends much upon the state of the weather and the water, but as a rule, the fishermen were engaged early in the morning and again in the afternoon.

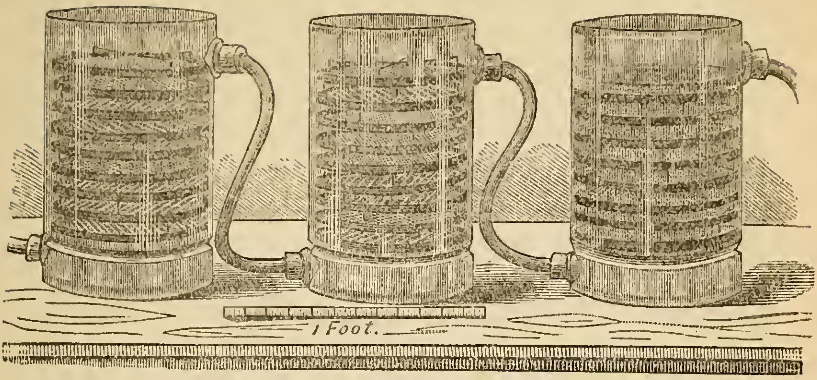
The catch of Smelt from the Raritan was very small the past season—1877—the fish seeming to decrease in numbers every year. This is not to be wondered at, considering the rapacity of the seiners, and their little sympathy, with some rare exceptions, with all efforts at increasing the supply by means of artificial propagation. The small and rather irregular catch of Smelt impeded, to a great extent, the work of the Commission, since at many hauls there were so few fish, that if ripe spawn was obtained, it was impossible to get ripe males to fertilize the spawn, and vice-versa.

And many hauls were entirely fruitless, so far as ripe fish were concerned.

The Commission began its work upon the Raritan on the 3d day of March, by taking possession of a small room in the N. E. end of the bridge-keeper's house, at the bridge entrance upon the S. W. bank of the Raritan, and separated from the river merely by the Raritan and Delaware canal.

In this room the apparatus was erected.

This consisted of six Ferguson hatching-jars,



attached by rubber tubes and stop-cocks to a central tub or reservoir, which was supplied with water from the city hydrant. This reservoir had a waste-pipe passing down its centre, so that the flow of water upon the jars could be regulated as completely as could be desired. The remaining apparatus consisted of trays, pans, pails, dippers, &c. for the purpose of manipulating the spawn. The methods employed by the Commission for the propagation of the young Smelt, were crude and imperfect, to the extent that they were trial methods, and that the accommodations were not such as were desired, but such only as could be obtained upon the spur of the moment, just when it was necessary to handle and care for the spawn.

The Commission had a somewhat difficult work before it, which was the handling, not only of a species of spawn which had never been successfully handled before, but of a species of adhesive spawn, and at the same time, if possible, to bring out a profitable result in the number of young fish hatched. Such work must always be more or less experimental ; if the experiments *happen* to be all right, the result will be very favorable in a fine lot of young fish ; but if the experiments are not all right, the result may be the entire loss of spawn, time, patience and money, and the latter is a very important item in conducting experiments in fish-culture.

Adhesive eggs had been treated, and successfully, before,[1] but it was a question whether the methods adopted in the case of such spawn as that of the Carp, Perch and Herring, would be suitable for spawn of an anadromous species of the *Salmonidæ* family, or whether such spawn should be treated simply as the non-adhesive type.

The only experience in treating Smelt spawn up to the time of the work of the Commission, was obtained by Mr. Charles G. Atkins, of Bucksport, Me. with the spawn of the Land-Locked[2] variety. At least this is the only experience cognizant to the Commission. This experience was not very favorable to the handling of this species of adhesive spawn, and, if I mistake not, Mr. Atkins' conclusions were that it would not pay to handle it.

A certain amount of the spawn which he had, hatched out, but only such portion as had the benefit of, and was exposed to, the full force of a rush of water ; in fact, that spawn only hatched which remained attached to grass, twigs, or other articles situated directly in a race-way, where the water rushed along very furiously. The spawn seemed to require, at least for its artificial culture, a constant and furious change of water, differing, undoubtedly, in this respect, very widely from its requirements when deposited by the fish upon its natural spawning grounds. The fish the Commission had to deal with were, on the contrary, anadromous, and we had no *rush* of water in which to deposit the spawn. It was also a question whether the Raritan Smelt spawn required this rushing change of water ; so the apparatus already described was employed as experimental upon the subject. The spawn was carried from the fishing grounds to the hatching-house in tin dishes. Sometimes, but rarely, the fish were taken to the hatching-room, and there spawned,

---

[1] See page 567 U. S. Fish Commissioner's report, 1872–73. Method of treating adhesive eggs, &c. by Rudolph Hessel.

[2] More properly fresh-water Smelt. They are sea Smelt which have been transferred to interior ponds and lakes, and becoming acclimated there, have ceased to return to the sea after they have deposited their spawn.

and the eggs impregnated. In the experiments of Mr. Atkins, he found that leaves of river grass formed the best attachment for the spawn, and that spawn attached to this grass, and allowed to move freely about in the rush of water already mentioned, hatched out comparatively well, whereas spawn treated in any other method, died. The grass, of course, was attached by one end, the other being free to move and sway in the current. The Commission tried various things upon which the spawn was deposited. Bits of grass; bits of untwisted rope warp; bits of gauze hanging free in the jars; loose masses of moss; and light small-meshed gauze, with which the ordinary spawn trays were covered. Many of the eggs, upon being placed in the water of the jars, and before becoming completely attached by the hardening mucous stalk, described, p. 58, would become swept from the trays or other objects, and fall to the bottom of the jars, where they, in some of the jars, formed quite large masses. These latter masses, being directly in the way of the current of water entering the jar, of course received a much more violent and fresher flow of water than the rest of the spawn. They were thus placed in very much the same condition as the spawn which did the best with Mr. Atkins, except that they were massed together, and also, excepting, of course, that the flow in the jars was never *violent*.

Mr. Wm. Hamlin did most of the practical work for the Commission, such as manipulating the fish and caring for the eggs in the jars, &c. The method of gathering and impregnating the spawn was as follows:

Three or four tin pans, with two or more gauze or twig covered trays in each, a tin-pail and a dipper were carried to the fishing grounds. As soon as a haul of the seine had been made, and the fish were all gathered together in small compass close to the shore, or upon it, they were immediately overhauled, and the *ripe* males and females laid to one side. The rest of the fish were gathered up by the fishermen, and

carried off to be sold at so much per bucket. The ripe females were then taken and held by the head, while the belly was gently pressed and stroked toward the anus, so as to force out the ripe spawn. The spawn was caught in a pan containing quite a little water, and when a sufficient quantity had been taken, that is, when the bottom of the dish was half or two-thirds covered, the ripe males were taken, pressed in the same manner, and the milt allowed to flow upon the spawn in the dish.

As the males were, as a rule, considerably smaller than the females, it required very often two, three or even four males to furnish milt to impregnate the spawn from a single female. Sometimes, but rarely, the milt from one male would be sufficient to impregnate the spawn from one or even more females.

Water was then added to the milted spawn, and the contents were stirred slowly and intimately until thoroughly mixed. This stirring was either done by swaying and tipping the dish back and forth, or by stirring the spawn with a feather. After being thoroughly mixed, the spawn was carefully poured upon the trays ready to receive it. Sometimes the spawn was taken directly upon the prepared trays, the trays being placed in water so that the gauze or twig covering would be barely wet, or barely covered with water. The milt was then received upon the spawn, more water added to the dish and the trays moved about gently from side to side, until the spawn and milt were thoroughly mixed. The trays were then carried to the hatching-jars, and deposited therein. With both of these methods of receiving the spawn, there resulted many dead eggs, and perhaps as many by one method as the other.

Ripe males were very scarce at the time when the most and ripest females were procured, and it is barely possible that the percentage of dead eggs was owing more to the lack of milt than to the method of handling. Shad eggs, which are in other respects much more delicate than Smelt eggs,

will bear much more handling than the Smelt eggs received at the hands of Mr. Hamlin by either method used. It was undoubtedly not the roughness of handling which occasioned loss. Another method of taking spawn was adopted. A number of large, unripe male and female Smelts were taken from the seines, carried to the hatching house, and kept in the supply reservoir until they became ripe. The spawn was then taken, impregnated, and placed in the jars along with the rest. On account of the lack of room, no record could be kept of the relative percentage of loss between eggs thus taken and eggs taken from the fish freshly caught. By examining the temperature and fish record upon another page, it will be seen that spawn was taken and placed in the hatching-jars upon 15 different days, extending over a little less than one month, or more correctly, from March 3d until April 2d. The whole number of ripe fish taken for the purposes of procuring spawn and milt being 87 males and 69 females. This irregular catch was due in great part to the almost constant recurrence of freshets, and consequently, risings and floodings of the river. On account of one of these freshets, a very severe one, produced by a long and steady rain-storm, only one catch was made from Friday, March 16th until Friday, March 23d, a space of one week. The ripe fish taken up to the time of this freshet were largely males. They were fairly ripe, and produced much more milt than those taken subsequently. The females, on the contrary, were barely ripe, and only a small quantity of spawn suitable for the purposes of the Commission, could be obtained from each. After the freshet, the females began to increase in number, Friday, the 23d of March, the largest catch of the season being made, and they were riper than those previously taken. From this time on, the females were taken in fine condition until the close of fishing. But the males were now so few in number, and the milt was so bad, that it was with extreme difficulty that the spawn could at times be satisfactorily impregnated. It is quite difficult

to arrive at an accurate estimate of the number of eggs taken from the 69 ripe females and deposited in the jars, but it was very roughly estimated at two millions. This was the estimate of Mr. Hamlin and myself, while at work with them at the hatching house. The estimate is larger in bulk than that attached to the record referred to, for the reason that we wished to give the record as much accuracy as possible, and to certainly have the record within the actual number. Our method of counting was this: I took an average sized female Smelt, removed the ovaries from her entire, took a small portion of the mass, weighed it, and then counted the number of eggs in this small portion.

I then weighed the entire remaining mass of spawn, and from this estimate arrived at the conclusion that there should be about fifty thousand (50,000,) eggs in a medium sized Smelt. By a medium sized Smelt I mean one of the size represented in Fig. 8, Pl. V. But of course many fish will not yield this number of eggs, and many will yield more.

Allowing forty thousand eggs to each female Smelt taken, we would have from the 69 females, a grand total of two million seven hundred and sixty thousand eggs (2,760,000).

But as many of the females were small, and as others did not yield a full amount of ripe spawn, if we estimate that they averaged just one-half that amount, or twenty thousand eggs (20,000,) per female, we shall have very nearly the sum total given in the record.

From the time the Commission began its work until the freshet, the temperature and weather had been fair. The thermometer had indicated a rise in the temperature of the air of about ten degrees, (10°,) and in the hydrant water which supplied the hatching-jars, of two degrees (2°); the temperature of the river had risen, during the same time, six or seven degrees (6° or 7°.) Up to this time the eggs had not progressed very favorably; many had died, and the rest were in such a condition that it was impossible to state as to whether they would survive or not. With the freshet already mentioned,

came a cold spell. The air thermometer indicated a decrease of, at its utmost, eighteen degrees (18°); the temperature of the river sank at same time about 12°; and the hydrant water received a sudden cold to the extent of about three degrees. Up to the end of this cold period, there was barely a sign of development in those eggs which were not certainly dead, and it was questionable what the result would be with the eggs which appeared to be living. But with the storm and freshet, the cold weather appeared to pass away. The temperature of the hydrant water rose steadily, and in a week's time had risen four or five degrees; and of course the rise in the air and river was much greater. With this rise in temperature a change in the eggs became visible; the development could be made out, and it was very soon evident that many of them at least were alive, and seemed in a fair way of producing each its young smelt. About the 26th or 27th of March I took some eggs which had been spawned on the 3d and 5th of the same month, and which showed some signs of development—in fact the embryo could be made out as a mere bar, very nearly alike at both ends, coiled around the yolk—and brought them into the room where I was at work with the microscope, and where the temperature was about 70°. I let them remain in the water in which they were brought in, and only changed it by adding fresh water as the other evaporated. The water which was added was such as had been in the room for some time, so that it was of considerable higher temperature than that of the hydrant. The eggs thus placed in comparatively stale and warm water, rapidly developed, and on the 3d of April a few of the young fish hatched out, or just one month from the time the spawn was taken. In the case of these young fish we ought to deduct at least two weeks, since there was hardly any devolopment of the embryo until the temperature of the hydrant water rose to near 40°. I think it can be said, with a considerable degree of certainty, that after impregnation, a certain, but very small degree of differentiation will take place when the

water is near the temperature of 37° or 38°, Farenheit; if this temperature becomes lowered the development will be retarded or checked entirely, and the vital processes held in abeyance until the temperature again rises to above 38°.

If the temperature of the water is raised much above 38°, as in the case already mentioned, the eggs are merely forced forward, as vegetables and plants are forced in a hot house, and we find the young fish developing very rapidly. The coldness of the water, and the subsequent cold snap lowering still more the temperature of the water, was undoubtedly the cause of the exceedingly slow differentiation which took place in the eggs up to the 20th of March. It has been known for a long time that snail eggs could be impregnated, development started, and then, by means of cold, be kept in a quiescent state for even a year or more, and afterwards, by allowing warmth to come to them, they could be developed into the perfect snail. That to a certain extent the retarding of the development can be made available with fish spawn, is undoubtedly the experience of every pisciculturist, but just to what limits it is best to retard or force the growth of the young embryo, is a question worthy of more study than it has yet received.[1] If the temperature is too low they will be too long developing; if too high they will be apt to be too delicate to survive in any water into which they may be transplanted. From the 20th of March on, the hydrant water rose steadily in temperature until the young fish were all hatched and transported to their final homes in the waters of Maryland. This rise of temperature was from 37° up to 50°, or a difference of 13°. The experience of this year's work with the smelt would seem to indicate that the spawn thrives best in water of a temperature from 40° upward, or perhaps I might say, in water of an average temperature of 44°.

Spawn taken and placed in water of this temperature would undoubtedly hatch out in from three to four weeks,

1See an address upon the artificial breeding of fishes, read before the Detroit Scientific Association by Mr. N. W. Clark, page 9, et seq.

and any work with spawn in water of a lower temperature would be in greater part lost time. Between the two extremes I think it would be much preferable, and more profitable to wait until the water is even 50°, before beginning operations, than to subject the eggs and the operators to the benumbing effects of 38°, and lower, of cold, for it is very possible that some of the eggs at least may be injured by this excess of cold. In case however the weather should be very cold again at the time of the work of the Commission, it might be a wise plan to take some of the spawn, dryly and carefully impregnated, particularly if it is very plenty at such time, pack it in ice, and keep it until the temperature moderates to about an average of 44°, and then place it in the hatching jars, and watch it very carefully, recording the result. I have already said that a great many of the eggs died. The greater portion of these dead eggs were upon the bits of grass, rope, moss and twigs, already mentioned, and the greater portion of fish came from those eggs which were taken on the trays, covered with gauze, and those eggs which were massed together in the bottom of the jars, in the strength of whatever current there was. The live fish which were hatched from the million and a half, or more, of eggs, were estimated at about four hundred thousand, (400,000), the remaining eggs being classified as "absent or unaccounted for." The work of the Commission may, with this result, be said to have been very successful, considering everything. I have said that the greater portion of these dead eggs were upon the moss, twigs, ropes, &c. and we might be led to judge that these objects were not as fitted for supports to the smelt spawn as the gauze, or the bottom of the jars. But it may be that these articles are not so very much to blame after all ; perhaps they are only fitter than the gauze to retain and encourage the growth of a species of fungus which was found in very great abundance in all the jars, sometimes covering the eggs upon the trays to a depth of an eighth of an inch or more.

This fungus, thus covering the eggs, must have a very deleterious effect upon them, and I do not think it would be very wrong to ascribe to it the death of a goodly portion of the eggs.

In considering the practical bearings of the work of the Commission during the past season, it may be useful to note a few points to which it will be well to pay particular attention, and record carefully the results during another year's work.

In handling eggs of any kind, the dry method[1] of impregnation should be adopted upon all occasions; that is, the eggs and milt should be placed together *before any water whatever is added;* a little water should then be added to the mass, and the whole shaken together quickly, yet completely, until the eggs and milt are thoroughly mixed; then more water should be added, a second shaking given, and after standing ten or fifteen minutes, the water, or the greater portion of it, poured off, and fresh added.

The eggs are now to remain quiet until transported to the hatching jars, and placed therein. I am convinced that this is the only practical method with adhesive spawn, and particularly with Smelt spawn, and I think the best results will follow, if the trays, covered with fine gauze, are used, upon which to receive the spawn and milt fresh from the fish. The meshes of the gauze covering should be just a little smaller than the diameter of the eggs, so that they will not pass through before they have had time to become attached. The gauze should be just dampened, the trays placed in a pan, without water, and the spawn shed upon them, the milt then being shed upon the spawn.

Water is then to be added, just sufficient to cover the trays, the whole shaken gently from side to side, so that the whole mass may be thoroughly mixed, but not so much that any of the spawn will be shaken from the trays, the spawn left

[1]Vrasski's method, as modified by Mr. C. G. Atkins, in his work upon the Salmon spawn. See United States Fish Commissioner's Report 1872–73, page 240.

to stand for ten or fifteen minutes, and then shaken again, when the water may be changed, by lifting the trays out of the pan, and fresh water added ; the trays may then be transferred, covered by water in the pans, to the hatching jars,[1] in the hatching house. In a very short time the mucous covering the egg will harden, and adhere to the gauze upon which it rests, and the egg will thus be attached firmly to its support. This method gives the least handling to the spawn, and accordingly the least chance for injury to the same. I have already intimated that perhaps a goodly portion of dead eggs were caused by there not being sufficient milt to impregnate all the eggs in any one dish.

Generally a considerable quantity of milt is considered necessary, because very little time is given to the manipulation of the spawn; and certainly the greater the amount of milt, the less the time necessary in manipulating. But with a very little milt a large number of eggs may be impregnated, if sufficient time is given, and the whole is well manipulated. The spawn and milt must also be fresh from the fish, and *brought together immediately*, upon water being added to either, since water soon acts upon the spawn, so as to prevent any effect upon it by the milt, unless the milt is added *very soon*. The method mentioned seems to combine all these requisites, and in the case of the spawn already mentioned, had the manipulation been more prolonged when milt was scarce, perhaps fewer eggs might have died. And I have no doubt at present time, that if, besides additional manipulation, the spawn and milt had been placed together dry, before any water at all had been added, a still larger proportion of live eggs would have been the result.

To obviate any such chance of lack of milt, although the stirring and shaking of the eggs should in all case be con-

---

[1]It will be noticed that I always speak of the *hatching jars*, meaning thereby the Ferguson hatching jar. This apparatus is so simple, and so exactly adapted for the purposes of hatching eggs or spawn of any description, that after trial I think no one will care to use any other description of hatching apparatus.

tinued for ten or fifteen minutes, the plan of keeping unripe fish in a reservoir until ripe, and then spawning them, should be adopted more extensively than this season.

They should be kept in a reservoir separate from that which supplies the hatching jars with water, since the fish are apt to be drawn against the openings into the supply pipes for the jars and the water thus cut off from the spawn, and stagnant water favors fungoid growths. They should also be examined carefully each day, so that as soon as ripe the spawn and milt may be taken from them, and yet not taken from them until they are fully ripe. In this manner a large quantity of spawn should be obtained, and unless the fish are injured there is no reason, so far as at present known, why such spawn should not turn out as well at that of Trout kept in a similar manner. Spawn taken from fish thus kept should be placed separate from that of spawn from fish taken fresh from the river, and the two carefully compared, after, of course, the same manipulation, so as to see which method is the better; records, of course, being kept of each. In making this experiment the largest fish should be kept as furnishing so many more eggs, or so much more milt than the small ones. But to carry out this experiment, more room will be required than was at the service of the Commission this season, and it would undoubtedly be better if accommodations of sufficient size could be secured near the fishing grounds, so as to obviate as much as possible the transfer or carriage of fish and spawn. The treatment of the eggs, after they are placed in the jars, does not differ materially from that of other spawn. A constant flow of water, and since the eggs adhere to their support, a much stronger flow through the jars, can be permitted, than with other eggs; clean jars and trays; and the removal of dead eggs. The removal of dead eggs, in the case of the Smelt spawn, is almost practically impossible, on account of the adherence of the eggs to each other, as well as to the sup-

port, and also, and chiefly, on account of their small size. Fig. 5, Pl. I.

But much can be done, with pains and attention, towards keeping the trays comparatively clear of dead material, and the greater the care and attention, the greater the success ought to be.

The only remaining point necessary to notice particularly is in regard to the dirt and fungus in the jars. Of course, in all waters subject to freshets, there will be more or less of sediment and floating material, which does not add at all to the purity of the water. The only way to prevent this material from getting into the jars, and collecting around and upon the eggs, thus forming an excellent basis for fungoid growth, is to have the water filtered before it is allowed to enter the reservoir which supplies the jars If the Commission should conduct operations upon the Raritan another year, and should use the river water, it would certainly have to be filtered, or the jars would very quickly be filled with sediment. If the hydrant water is used, it also should be filtered, although, as compared with the river water, very free from floating material. As regards fungoid growths, they appear to get into the jars about as easily when the water is filtered as when it is not, the only, or at least the great difference being, that in unfiltered water there is a vast amount of vile material which fosters and encourages these fungi. The best method of disposing of them is to give the eggs, as soon as any fungus appears upon them, a salt water bath. Let the water be shut off from the jars, a table spoonfull or so of salt added to the water in each jar, and then allowed to stand for fifteen or twenty minutes, when the water should be turned on again. The salt will effectually kill all the fungi, without injuring the eggs, and the renewed flow of water will carry off the salt and the dead matter in its flow. As soon as the fungus again collects upon the eggs, they should be treated to another salt bath.

If any doubt is felt in regard to any possible injurious

effect which the salt might have upon the Smelt spawn, a trial could be very easily made of one of the jars only, and the result noted, i. e., as to whether there were any more dead eggs in the jar after the salt bath than before. The salt bath is very effectual, and perfectly innocuous with Trout eggs and aquaria, and there is no reason to suppose it would be otherwise with the eggs of the Smelt. With the growth and extension of fungi in the jars thus prevented, and with that care in the manipulation of the spawn which I have suggested, the Commission ought, with the experience of the present season, to be able to work as successfully hereafter with Smelt spawn as they have shown themselves to be with spawn which is non-adhesive, such as that of the Trout and Shad.

The work of the Commission, from nececsity, as well as inclination, is to increase the food supply as profitably to the State as possible, and while the matter of profitable propagation rests to a great extent in the hands of the Commission, through the experience which is gained each year, yet other circumstances enter largely into these calculations, such, for instance, as their ability to do as they would like, and to work just at the time they desire. If in the propagation of the Smelt the Commission could so arrange their time for work upon the Raritan as to be there when the temperature of the water used in the hatching jars is from 42° to 44° at an average, they would undoubtedly meet with the greatest and best success, especially in a pecuniary point of view, since at such a temperature the young fish could be hatched out in about three weeks.

The most serious objection to this plan is in the running of the fish themselves, the greater portion of the fish passing into the river earlier in the season. But if the method is adopted of keeping the males and females in confinement until ripe, even this objection might have very little weight, and the spawn might be handled at a time when it could be so done most expeditiously and profitably.

In recapitulation, I might say that the important points to the Commission for its work another year would be, 1st, the procuring of suitable fish. 2d. The careful manipulation of the spawn *absolutely dry*, or the nearest convenient approach to it. 3d. The temperature of the water, about 44°, and its freedom from fungi.

——o——

EMBRYOLOGY OF THE SMELT.

The following notes upon the embryology of the Raritan river Smelt were made in March and April, 1877, at New Brunswick, N. J., while the Commission was engaged in prosecuting the hatching of Smelt spawn, the methods of which process have already been described. I do not intend to treat of the histological development of the Smelt—or of its minute cell structure—except so far as it can be made out in the living specimen ; since a histological study, made from sections cut from hardened specimens, is of value and interest only to science and scientific students, not to the general reader. This paper will, therefore, serve merely as the basis of what I trust, at some future time, to make a histological research, and hence, must be taken with that allowance for error, both in the personal equation and the equation of sight, to which all research is liable when unauthenticated by collateral or different methods.

My method of study was either to take the eggs from the hatching jars, one or more at a time, and examine them upon a watch-glass in a few drops of water, or to dissect the vitelline membrane or shell from the egg, and examine the uncovered embryo in a drop of water, or sodic-chloride, Na. Cl. $\frac{1}{2}$%, upon a glass slide, under a low objective in the microscope. In this manner I examined egg after egg, until I became satisfied upon any or all observed conditions, and was able to trace a pretty clear sequence of developments. My investigations were made with Zeiss oculars 2 and 4, and objectives A and B, giving a range of power from 90 to 400 diameters.

In the case of the milt, I used Zeiss ocular 4, and objective F, giving an enlargement of 950 diameters.

The Egg.

The freshly laid egg varies in diameter from $\frac{1}{50}$ to $\frac{1}{30}$ of an inch, and is somewhat irregular in outline, although generally round or oval. Fig. 1, Pl I. The number of eggs which an average size fish will spawn is about forty thousand. I estimated, by weighing and counting, the number in a female Smelt $7\frac{1}{4}$ inches long, from Little Narragansett Bay, R. I., to be seventy thousand, and this after making due allowance for errors. The average length of fish from the Raritan river is less than this, and will not fall far short of 5 inches.

The eggs, as they issue from the female, are enclosed in or surrounded by a mucous or viscid substance, which seems to form a sort of protection for the egg. This viscid substance has a tendency to adhere to whatever it touches—and, although the eggs separate as soon as they touch the water, yet if in passing toward the bottom they touch any object, such as a leaf, twig, or bit of weed, they remain attached to it. The water then appears to act as a hardening agent upon this viscid coating, causing it to "set" in the form of a sack around the egg, with a slender stalk or handle between the egg and its attachment. Fig. 8, Pl. I. Sometimes a number of eggs remain in a little bunch together, or are gathered together by falling one upon another; the "setting" of the mucous around each one then transforms them into a cluster, Fig 5, Pl. I, much resembling the egg clusters of the Cray-fish. This outer coating of the egg or ovum presents a granulated or dotted appearance as if having a great number of pores or openings; but I have been able to discover no openings in small pieces of the shell, even with Zeiss ocular 4, objective F, and am inclined to believe it the effect of the hardening or "setting" process.

Fig. 8, Pl. I. The unimpregnated ovum or egg, freshly taken from the female and divested from the mucous coating, presents a vitelline membrane or shell entirely filled with highly refractile oil globules of very nearly uniform size. These oil-globules constitute the vitellus.

The vitelline membrane has upon one side a very prominent depression or pit—the micropyle—with an undoubted opening or pore at the bottom. Figs. 1 and 2, Pl. I.

This micropyle at first indents the mass of oil-globules, but as soon as the egg passes into water, some of it is absorbed, and the vitellus shrinks in bulk and occupies a smaller space in the centre of the egg. Fig. 2, Pl. I.

From the absorption of water the micropyle soon becomes obliterated and its place simply indicated at first by a slight protrusion of the vitelline membrane, Fig. 3, Pl. I, afterwards by a puckering of the surface, Fig. 4, Pl. I, which is observed in some eggs when the embryo is very far advanced. In many, or perhaps most eggs, however, all traces of the position of the micropyle disappear soon after impregnation.

The absorption of water slightly increases the size of the ovum, although very slightly, the great change being the concentration of the yolk-mass. This distention of the vitelline membrane of course has very much to do with the disappearance of the micropyle. The micropyle is not constant in position as regards the stalk of the mucous sack, nor as regards the position of the embryo, sometimes being over the head, sometimes over the tail, sometimes to one side.

This latter relationship, however, is of no special importance, since the yolk-mass is movable, and the position of the micropyle, with relation to the embryo, thus a constantly changing one, with every motion of the egg. After the absorption of water, the concentration of the yolk-mass, and the filling out of the vitelline membrane, the vitellus or yolk-mass becomes somewhat changed in character; the oil-globules unite one into another directly, forming larger spheres in the centre of the mass, with smaller ones filling

up the interstices and forming a layer around the outside or periphery. This change continues until the outer portion assumes a mottled granular appearance. One side—and it is always on the side—then assumes a lighter shade, becomes very evenly, finely granular, and forms a less or greater protuberance from the vitellus. Fig. 3, Pl. I. This form continues with more or less distinctness, sometimes assuming the fissural condition of segmenting or impregnated eggs, until the yolk gradually turns white, disintegrated, and dies.

I was unable to find among the oil-globules of the vitellus, any germinal vesicle with its germinal dot, although I opened a great number of ova, and examined the contents with Zeiss ocular 4 and objective D, giving 400 diameters enlargement. I did find, however, in most of the ova, a small bit of granular tissue, which may represent the germinal vesicle, or more properly, perhaps, the blastodermic tissue. I am inclined to think that the germinal vesicle undergoes a differentiation during the period of ripening of the egg; and although no true segmentation takes place until after contact with the male element, yet a granulation takes place which changes the vesicle with its contents, into blastodermic tissue, ready to be segmented and still further differentiated upon contact with the male element, or without contact, to disintegrate. It is highly probable that in an earlier stage than I have examined, the vesicle, with its contained germinal dot, can be found.

Spermatozoa.

The milt in the male occupies relatively less bulk than the spawn in the female; and the males can thus be designated from the females, during the spawning season, by their more slender form, there being very little of what is vulgarly known as pot-belliedness about them.

The spermatozoa or male elements are very numerous in the milt, and present an appearance very much resembling grains of wheat, Fig. 6, Pl. I, rolling and jerking across the field of the microscope. In some of the spermatozoa I discovered a very slight prolongation at one end, but other than this, could see no indication, either when in motion or still, of any tail, or long, slender, filamentous appendage such as is found in all other vertebrate spermatozoa, so far as my knowledge extends. The spermatozoa are very small, however, and as I had no means of viewing them with greater magnitude than 950 diameters; and as they then appeared mere specks upon the field, this observation in regard to the tail is far from reliable. How and where the spermatozoa pass through the vitelline membrane into the ovum, and impregnate it, has long been a mooted question. That in this species they pass in through the opening in the micropyle, however, and are drawn in with the water which the ovum absorbs, cannot, I think, be questioned.

At least this much is known, that if the dry method of milting the spawn is adopted: that is, putting the milt and spawn together before any, or when very little water has been placed with the spawn, and afterwards placing them in water and shaking together gently, the proportion of eggs which fail to be impregnated, or to do well, is very small indeed; but if the spawn be allowed to remain in water for even a very short time before the milt is added, in fact, until by absorption the micropyle has become obliterated, the proportion of eggs which turn out unimpregnated and bad is very large indeed. To test the question as to whether spermatozoa were actually taken into the ovum during this season of water absorption, I took a Smelt egg which had had milt shed over it, and as soon as it had ceased absorbing water, or as soon as it was apparently full of water, carefully removed the mucous and washed it in six waters, so as to remove any spermatozoa which might be upon the outside. I then took off the vitelline membrane, and allowed the yolk

contents to escape upon a glass slide. The escaped vitellus was then examined with Zeiss ocular 4, objectives D and F, and I was able to discover a few spermatozoa among the oil-globules.

This may be considered as not entirely conclusive, but it is questionable if any *more* conclusive method can be adopted, since it is utterly impossible to see the spermatozoa penetrate the ovum through the vitelline membrane, either at the micropyle or elsewhere, on account of the relative sizes of ova and of spermatozoa.

Impregnated Ovum.

For quite a time after the ovum has been impregnated, there is no perceptible difference in the changes which take place from those in the unimpregnated egg. One side becomes clearer, Fig. 4, Pl. I, with fine granulations, a portion protrudes, and then take place those segmental phases, some of which are represented in Figs 9, 10 and 11, Pl. I

These changes were very slow in taking place in the eggs of the Smelt, probably on account of the sudden lowering of temperature which took place about the time that most of the eggs were taken and continued for a week or more. Hence many of these changes were overlooked in the confusion of observing ova in the earlier phases, and all stages of living and dying, and accordingly I lack a complete series of the segmentation stages. These stages are undoubtedly similar, however, to those in the egg of the shad, a description of which changes will be given in another place. The fine granular portion which results from this segmental differentiation, gradually extends for quite a distance around the periphery of the egg, Fig. 7, Pl. I, and represents the blastodermic tissue, or simply blastoderm, from which the young fish is to be built up. Previous to, or during the formation of the clear granular portion, there were no indications of any polar globules* at this or any other portion of

* Richtungsblattchen or direction cells of authors.

the vitellus, but merely the protrusion of one side into a more or less prominent limb. Fig. 3, Pl. I. In certain ova, however, glomeration did take place: that is, round balls, sometimes one above the other, formed irregularly over the blastodermic tissue, and I noticed that such formations, in both Smelt and Shad ova, heralded always the disintegration of the vitellus. Sometimes this glomeration took place after the embryo was considerably formed. In all cases, however, no further development took place, the ovum soon becoming opaque and dead. Coincident, or nearly so, with the extension of the blastoderm is the formation from the blastoderm over the entire surface of the vitellus, of a layer of cells, the exoderm, (epiblast),* which forms the outer coat or skin of the embryo.

The folding which this layer undergoes along what is to be the dorsum of the embryo, I was unable to make out satisfactorily, on account of the difficulty of keeping the blastoderm in a proper position for study under the microscope. Almost as soon as it was got into a good position, it would roll slowly back to the side. I thought I made out, however, in a number of specimens, the folding in different stages of its progress.

This folding consists of the growing up along the central portion of the blastoderm of two laminæ or ridges from the exoderm. These laminæ finally unite along a median line, leaving a central cavity or tube the length of the folding,

---

* I use the terms *exoderm* and *endoderm* as being more exact in meaning than epiblast and hypoblast. The exodermic layer is with fishes, very rarely formed upon the *upper* side of the blastoderm, yet, according to the meaning of the terms, when the epiblast is formed below, or on the lower side of the blastoderm, it would become the hypoblast. In the same manner the hypoblast or under blast, when formed above the blastoderm, would become the epiblast I use these terms also because they are used for simiiar or homologous structures among the lower forms of animal life. And similarity is much to be desired in names bearing upon or attached to homologous structures.

which forms the neural or spinal arch of the embryo, or the arch in which the spinal cord is formed.

Within the exoderm, and from the within-lying cells of the blastoderm, two other layers are subsquently formed—the mesoderm or middle layer, and the endoderm (hypoblast) or internal layer. From the folding in and union of these two layers in conjunction with the exoderm, a second arch, the body or alimentary cavity, is formed. The further growth of the embryo then takes place through differentiations, either slow or more rapid, in the three layers making up these two arches. The first indication in the egg of the Smelt of anything approaching a fish or animal in form, is represented in Fig. 1, Pl. II.

Here the folding in of the exoderm to form the neural arch is nearly completed, the anterior and posterior ends being still open, although only the anterior end can be seen. At this anterior end is seen quite an enlargement, which represents the swelling of the cerebral vesicles, or what will eventually become lobes of the brain. This end increases still more in size, the lobes appearing to swell out with a more rounded appearance, and just before the anterior end of the neural canal closes, round, disk-like markings appear upon the middle portion of the sides of the head—as we shall hereafter call this end of the embryo. These markings, Fig. 2, Pl. II, represent the first indications of the eye-balls.

The head presents, at this period, a very dumpy or club-shaped appearance, with its prominent lobes and rather thick lip-like edges of the closing neural canal. Very nearly with the appearance of the eye protuberances, or very soon after, can be seen a cylindrical tube containing two rows of large cells side by side, which barely touch in any part, and are somewhat scattered posteriorly, extending nearly the entire length of the embryo, just along the ventral side of the neural arch. This is the notochord or the axial portion of the future back-bone. Fig. 2, Pl. III. It ends anteriorly, with a quite abruptly bent extremity, just on a line with the pos-

terior edge of the eyes; and posteriorly loses itself without bend in the tissue near the centre of the tail, just ventral to the closed end of the neural canal.

Closely investing the notochord, and coincident with its formation, can be seen a sort of blocking-off into cell-like sections in the posterior, two-thirds of the embryo. Fig. 4, Pl. II. These sections or proto-vertebræ are not seen in the anterior third, but become gradually lost in tho tissue. They are bounded by a well marked line, which passes parallel to and at some distance from the contour line of the body, around the posterior end of the notochord, and proceeding forward, becomes lost in the tissue coincident with the segments themselves. These segments gradually increase in number with the growth of the embryo.

The least number which I noticed in any specimen after the head was differentiated so as to be distinguished, was 24; from this they increased up to 50, beyond which number I believe I did not count.

The portion thus segmented becomes eventually the harder, axial part of the body, containing the greater part of the osseous material, the spinal cord and the main blood-vessels. Up to this time, the embryo has been united throughout its entire length to the vitellus. But a change soon takes place; the layers of the embryo, which meanwhile have been forming from the tissue lying within the exoderm, begin to fold in to form the second cavity. This frees the posterior end of the embryo gradually from the vitellus, and allows it to project between the vitellus and the shell membrane, where, by the growth of tissue and multiplication of segments, it gradually extends until it wraps itself completely around the yolk, and passes by the head on the opposite side. Fig. 7, Pl. II.

As the tail becomes free, the eyes become more prominent, and the ears are indicated by slight depressions in the exoderm upon the sides of the body, just over the bend in the anterior part of the notochord.

A depression of the exoderm now takes place over the center of the eye-ball, which, being a mere sack, is depressed into a one-sided cup to receive the bit of exoderm. This bit of exoderm is then surrounded and enclosed by the sides of the cup, it becomes detached from the exodermic layer, and becomes gradually transformed into the chrystalline lens. As the lens and cup undergo changes, the edge of the cup is so modified that it shuts in the lens much as a watch glass in a watch is enclosed by its rim. Fig. 9, Pl. II. This closing of the eye-sack around the lens, is from the dorsal towards the ventral side, and after the lens is completely embedded, the line of contact of the sides of the sack can be seen running from the edge of the lens down and along the ventral surface of the eye, until it becomes lost in the brain mass Fig. 1, Pl. III.

By this time the ear cavity has become quite prominent, surrounded by its hemisphere of columnar cells, with the otoliths becoming visible as small transparent bodies in the ventral side of the bottom of the cavity. Fig. 5, Pl. II. The brain can also be made out as a tube-like body, with a prominent, posterior fold, open at both ends and along the dorsal side, and having a diamond shaped expansion of the dorsal slit about two-thirds the distance from the anterior end. This expansion represents the third ventricle. The posterior fold presents two laminæ, curving upward, inward and forward, which gradually grow together, and ultimately unite upon the median line dorsally, to form the cerebellum; the depression just posterior to the fold, or the posterior open end of the brain, becoming the fourth ventricle. The eye sacks appear attached to the central ventral portion of the brain tube. Fig. 9, Pl. II.

They are in fact expansions, and hence, differentiations of the middle cerebral vesicle. The nasal pouches are indicated at this time, by circular markings just anterior to the eyes. As the infolding of the layers continues, or more properly, as the embryo grows away from its original con-

nection with the yolk-sack, the organs which have indicated specialization become still more highly specialized. The eye acquires pigment granules; the ear becomes nearly enclosed by the approximation of its walls, and the otoliths are three quite prominent dark bodies ; the nasal pouch has deepened and rests against the anterior dorsal portion of the introverted brain ; the brain has increased in size, and shows indications of the different portions into which it is subsequently divided ; the head, which up to this time has remained attached to the yolk mass, becomes free as far back as to the posterior edge of the eye ; the first indication of an intestine, is seen in a blind hollow space in the tissue, where the tail is growing away from the yolk, Fig. 2, Pl. III ; and beneath the ear, at the junction of the embryo with the yolk, is a rather sharply marked tract, rounded posteriorly and somewhat pointed anteriorly, in which the heart soon is formed from the mass of loose cellular substance therein contained.

The branchial fissures are indicated at this later stage, by two or three streaks or slight transverse linear depressions along the sides of the body, posterior to the eye-balls.

Fig. 2, Pl. III, represents the embryo at a period a trifle later than this, or just after the formation of the heart, and about the time it begins to beat or pulsate. The embryo has been removed from the egg, by tearing apart the vitelline membrane, the yolk remaining unruptured. The embryo nearly surrounds the yolk ; the tail, up to where the vent or anus will be, and a small bit of the head, being free. The heart is plainly visible, and the branchial lineations indicated. The endoderm is now represented as the lining to the alimentary canal or intestine, or at least such portion of the canal as now exists, since the blind posterior extremity thus far alone is formed, and is all that represents the future intestine, the remainder of the to-be canal being filled up with the mass of the vitellus. Very soon, however, there takes place from below the ear, backwards, an infolding of

the layers of the blastoderm, forming, beneath the ventrally bending end of the notochord, an anterior cæcum. Meanwhile the infolding at the posterior end has been going on, so that now we have something much more like a canal; two cæcal extremities with connecting dorsal and lateral walls, and a ventral wall, open for a space along the centre over the yolk, thus still giving the embryo a connection with its food-bag, the vitellus, through the intestine. Fig. 1, Pl. III. The walls of the intestine are of course formed by the layer of endoderm. At this time, and before the intestine is entirely shut off from the vitellus by the infolding blastodermic layers, a large vacuole appears puffing out the body wall where the anus eventually opens, and separated from the posterior end of the blind intestine by quite a mass of loose cell substance. Fig. 3, *b*, Pl. III.

The heart is now becoming quite well defined, and is beating at the rate of about thirty-five pulsations per minute. At first the heart is somewhat more rounded at one end than at the other, forming a simple sack, consisting of a layer of columnar cells, and attached by bands of tissue at either end to the body proper of the embryo. I do not mention whether anterior or posterior end of the heart is the rounder extremity, because I am not positive from the observations made, that the rounder end is constantly in the same position. If I was to make an assertion, I should say that it was not constant.

Soon the heart becomes elongated and tubular, Fig. 4, Pl III, and its action in beating is much like that of a water-wave. The impulse begins posteriorly by expanding the posterior part of the tube, thus pushing the lower back portion of the tube still farther back towards the yolk mass, and stretching nearly straight the remaining portion.

The impulse then passes forward, allowing the posterior part to return to its former position, and swelling out the central portion until the impulse and dilatation have passed to the anterior extremity, when the conditions are just the

reverse of what they were at first. The action taken as a whole, is very much as if we took hold of the heart by one extremity and by a quick twitch should send a wave of translation from one extremity to the other. This gives a very curious and beautiful effect, as seen under the lens.

The heart soon looses this tubular form, becomes thicker at the posterior extremity and constricted in the middle, and passes by gradual steps into a two chambered organ. Fig. 5, Pl. III. Figs. 1, 2, 4, Pl. IV. At the same time it increases in its number of beats per minute, up to seventy, beyond which I believe I did not count. Nearly simultaneous with the assumption of the tubular shape of the heart, vesicles appear in the body tissue along the side of the body at the anterior end of the alimentary canal, between the branchial surface depressions already noticed. Figs. 1 and 5, Pl. III, Fig. 1, Pl. IV.

These vesicles increase in number until there are five on each side. The tissue composing their inner and outer walls then appears to grow thinner, until finally an opening takes place on the inside into the alimentary canal. Fig. 1, Pl. IV. The vesicles then disappear, and we next have the five branchial slits in their places. Fig. 3, Pl. IV. These slits represent the future branchial or gill openings, or the spaces between the gills; and the bits of tissue between the slits represent the future branchial arches, or become what are more commonly known as gills, there being four on each side, or four pairs in all, in all osseous or bony fish. The anterior border of the first branchial slit gradually grows backward, covering the rest of the openings, and becomes the operculum or gill-cover. Before this change takes place, however, and while the branchial fissures are yet mere slits through the tissue of the body walls into the alimentary canal, the yolk mass has been growing smaller and smaller, and the oil globules have been merging into each other, until we have a large spherical oil-mass or globule formed in the fore part of the yolk sack, Fig. 4, Pl IV, and the remainder of the yolk

composed of a finely divided granular mass, with the yolk at last entirely separated from the intestinal tract by the infolding blastodermic layers. A depression now takes place in the anterior end of the body and upon the under surface of the head, and gradually deepening, until it reaches the anterior end of the already formed intestine, becomes the mouth and œsophagus. In Fig. 4, Pl. IV, this newly formed mouth opening is represented, together with the general shape of the heart; the shape of the yolk mass; the ear now enclosed, with its otoliths; the pectoral fin, which began to show at about the time the heart was in its tubular condition; the notochord with its double row of cells, only one row being visible; and just beneath the notochord, the intestine which has now become either a solid rod of cell material or a tube with the merest trace of a central canal—this can only be decided by sections, which I have not as yet made.

Figs. 5 and 6, Pl. IV, will give an idea of the posterior end of the body, and the portion at the posterior extremity of the intestine, at about this time. These portions are very much enlarged, and show that a differentation is taking place in the tissue between the intestine and the notochord, and two separated tracts *a* and *b* are forming in which shortly the great blood-vessels are to be found. These tracts are not as yet extended as far back as the posterior end of the notochord, but their formation is indicated by spaces in the tissue along beneath the notochord. Fig. 5, Pl. IV. A magnified view of the anal portion of the embryo at the time of the formation of the anterior end of the intestine, and while the anal vesicle is still to be seen, shows that these two tracts are forming even then in the tissue above the already formed posterior end of the intestine. Fig. 3, *a*, Pl. III. At the time of development represented by Fig. 6, Pl. IV, the anal vesicle has disappeared, and the cellular mass indicates plainly an outlet tract, although no vent is as yet present between the posterior end of the intestine *c* and the exterior. Up to this time, the young fish has been retain-

ed by the vitelline membrane within the egg. It now, however, at about this stage of development, becomes free from the egg, and swims freely about in the water, looking to the naked eye very much like an animated bit of isin-glass with two black dots at the end. At this time it is somewhat less than three-eighths of an inch in length, and being very transparent, could hardly be seen in the water, were it not for the comparatively large black eyes. Side and top views of the young Smelt at this stage, but very much enlarged, are given in Figs. 1 and 2, Pl. V. Most of the structures and organs already mentioned can be readily seen; the intestine passing along the centre of the body beneath the notochord and above the yolk mass, from mouth to anus; the heart with its posterior and anterior attachments, now not only divided into two distinct portions, but relatively much smaller than heretofore, and the auricle crowded forward upon the ventricle; the ear with its forming semi-circular canals; the nasal sack somewhat closed; the prominent pigmented eyes; the much enlarged pectoral fins; the yolk mass, now much absorbed in nourishing the body, and gradually becoming enclosed by the body walls; and the quite advanced brain. The further stages of the brain may be seen by consulting Figs. 10, 14 and 15, Pl. V. In Figs. 10 and 15, Pl. V, the brain presents the same general features as in Fig. 2, Pl. V, with the exception that all the divisions are more strongly marked.

The posterior lobes are gradually approaching each other to unite on the median line dorsally, and form the cerebellum, while the prominent portions immediately in front of the cerebellic divisions are thickening and rounding out to become the optic lobes, and the anterior part is also changing form to finally assume the shape of the cerebral and olfactory lobes. In Fig. 14, Pl. V, these parts are represented as seen in the adult fish and of natural size. The brain, as thus seen from above, forms what the fishermen call the "old man's face," seen in the adult Smelt, through the

semi-transparent skull, by scraping off the over-lying skin. Soon after the stage represented in Fig. 1, Pl. V, the young Smelt begins to undergo quite considerable changes in form; the head is no longer roundish or blunt in front, but becomes sharp and rather shovel-nozed, from the rapid extension of the lower jaw or mandible ; the yolk mass is entirely within the limits of the body, and fast disappearing ; the vent has formed, and there is a marked depression of the body between the heart and the anterior extremity of the yolk ; the intestine again shows as an open tube, with the portion from the yolk to the anus much broader and larger than anteriorly ; the heart is in shape much as before, but now a few small particles can be seen moving around in the cavities of the auricle and ventricle, and the anterior and posterior connections of the heart with the body are much more marked. These are all represented in Fig. 4, Pl. V. During this last stage, vessels have been forming in each visceral arch, and one very prominent one, and traces of a second, in the tissue anterior to the first visceral cleft, or in what we may now call the operculum.

These vessels gradually extend themselves upward along the arches and sides of the head, until they reach the level of the ears ; from this point they vary in their development both in time and form. The prominent vessel of the operculum, which is really the second branchial aorta, and will be spoken of as such henceforth, developes very rapidly, and, from the position it has already attained, turns forward, downward and inward, and having reached a position just inside the eye ball, divides into three branches, one branch going into the ball of the eye and passing around the chrystalline lens, emerges and passes backwards ; one branch goes forward to the fore-part of the brain, bends around this and returns nearly upon itself ; while a third branch passes inward and upward into the brain tissue, to unite on the median line and near the centre of the brain, with its twin branch from the second branchial aorta of the other side.

Almost as soon as they unite they again divide, a branch passing to each side through the brain tissue, and at a point somewhat posterior to their division, they unite with the two returning branches already mentioned, to form lateral vessels, one on each side of and just along the base of the brain, which pass into the auricle, and so form a complete circuit of vessels for blood transmission; for by this time a passage has been made from the ventricle along the floor of the head, and just beneath the œsophagus, to the already mentioned branchial vessels.

Through the passage-way thus formed, a flow of blood, or some kind of fluid containing roundish or irregular bits of tissue material, takes place. This flow of blood serum, with its white or transparent corpuscles, through the 2d branchial vessels, forms, in the young Smelt, the first blood-system, which is entirely a head circulation. Fig. 3, Pl. V. The same thing takes place in the Shad. Up to this time no connection exists between the rest of the branchial vessels and the 2d vessel, or between each other. But soon the 3d, 4th and 5th vessels turn forward and unite into a common vessel, which passes forward to supply the head and brain with blood, and which, sooner or later, unites with the dorsal branch from the 2d branchial vessel, since all the branches eventually unite into the vessels (jugular veins), which run along the basal side of the brain to return the blood to the heart. The sixth branchial aorta, which originates from the fifth, passes directly upward, inward and backward, until, upon the median line, it unites with its fellow branch of the opposite side to form an open, isolated tube around the head, which has connection only with the ventral aorta through the fifth vessel, just anterior to the bulbus arteriosus, which, by this time, has formed in front of the ventricle of the heart, and connected with it. During the time the first circulation is in progress, corpuscles can be followed from the heart into these posterior four pairs of partially excavated vessels, where they are stopped in their onward

flow, and the corpuscles perform piston-like movements, back and forth, to and from the closed ends of the vessels, at each and every pulsation of the heart. Sometimes the corpuscles form quite a mass in these closed vessels.

They get out of the main blood flow, are driven into the vessels, and become clogged in these until the vessels open at their extremity. Shortly after this, a dorsal, lateral communication is made between the 5th and 6th vessels ; then we often see corpuscles passing up from the ventral aorta into the 5th vessel, and from this through the new channel into the still closed 6th vessel : or corpuscles will often pass into the 6th vessel, and when they come to the channel to the 5th, pass into it, and so on into the circulation. It is only a short time after this, and often perhaps coincident with the formation of the connection between the 5th and 6th vessels, that an opening takes place in the median line of the ventral side of the united 6th pair of vessels, and this opening leads into the dorsal aorta of the body. The body aorta passes directly back to near the extremity of the notochord, where it bends upon itself and returns as the vena cava, just beneath the aorta, to empty with the jugulars into the Cuvierian sinus of the auricle of the heart. From the aorta are given off, at different parts of the body, a great number of small arteries, which are distributed to different parts of the body. In most fish and other vertebrata, the principal arteries thus given off in the embryo are the omphalo-meseraic arteries, which pass to and over the vitellus. In the Trout and Salmon there are two of these arteries, one, the most anterior, passing directly to the yolk, a second passing along the upper side of the intestine, supplying it with blood, and returning along its ventral side, to unite with the first omphalo-meseraic artery, and then, dividing into innumerable capillaries, pass over the vitellus, to be gathered together once more, and empty their contents through the omphalo-meseraic vein or veins—sometimes there is only one, sometimes two—into the Cuvierian sinus of the auricle. In the

Shad, Lake-Herring and White-fish there is only one of these arteries. In the Smelt there is none at all, since the yolk, by this time, is entirely absorbed, undoubtedly by absorption from cell to cell, without any assistance from the blood-vessels. Fig. 4, Pl. V, shows the yolk nearly absorbed, with the liver just forming at its posterior dorsal extremity. There is no blood flowing in any part of the young Smelt at this time. When the yolk and liver become as shown in Figs. 6 and 7, Pl. V, with the central spherical mass of the yolk of a decided yellow color, and so as to be barely discernible in the living fish, we can discover the 1st circulation of the blood. The other arteries given off from the aorta are distributed along the entire length of the body. As a rule, an artery is given off to supply each vertebral segment of the body, and to each of the pectoral fins. In the tail, the aorta is at first, as already stated, simply folded upon itself; soon, however, it divides into three branches, or more properly, a connection is made between the aorta and vena cava, at a short distance from the posterior extremity of the vessels, thus making a little shorter passage for the blood ; and through this new passage most of the blood flows. Where this connection link is made from the aorta, a third vessel is formed, which passes upward and forward around the notochord, near its posterior end. The branch which was the original end fold of the aorta, still persists and supplies blood to the end of the notochord. The connecting-link branch, through which most of the blood now returns to the heart, gradually lengthens, so as to become as long as the primitive branch, is divided up into capillaries, one of which is sent to each ray of the tail, and becomes, in fact, *the* caudal artery. It is at the branching of these three arteries that the so called "caudal heart" of fishes is found. It is no heart at all, and there are no pulsations there, except such as are seen in all arteries, and due to the same cause. It is true there is a slight enlargement at this point, and sometimes the enlargement is considerable, but it is due

wholly to the sudden stoppage of the rapid on-rush of the blood driven from the heart, by the branching of the aorta and the sudden bending upon itself of the main return branch. The blood cannot escape fast enough into the smaller vessels and around the curve, and so is piled up at this point,* stretching the elastic walls of the aörta into quite a cavity, and, by forming a sort of cushion for the impulses of the heart, magnifies the beat; and this, together with the natural rebound of elastic walls when tightly stretched and then released, gives the "caudal heart."

In Trout and Salmon, and especially in Lake-Herring, there might with equal justice be said to be a "yolk heart," since where the omphalo-meseraic artery, or arteries, pass from the aorta, there are dilatations of the vessels, and the same "beating" appearance is seen. In the head a great many small arteries are sent off, which ramify through the brain and surrounding tissue. The position of these new vessels, and of the branchial vessels, after they pass into the head tissues, is continually changing and approximating toward a central vessel on the ventral surface of the brain, which is to unite with the body aorta, and form a connection between all the branchial vessels and the aorta, so that by far the greater portion of the blood shall make the complete circuit of the body before returning to the heart. I was not able to see this change in the Smelt, on account of the impossibility of keeping the young fry alive. They would not feed. My observations upon the development of the Smelt, therefore, end at this point. Much of the embryology of this paper requires to be further authenticated by examination and sections. This work I hope to perform at no distant day.

---

* Quære. Does this offer any suggestion as to the original formation of a heart?

Is a heart homologically simply an improvised dilatation, for retarded blood, of a branched or bending vessel, and a dilatation in which the rythmical pulsations, originally impressed upon it from without, have become inherited, and are now originated and perpetuated by it through a force which has become a part of itself?

VARIATION IN THE SMELT.

While at work upon the embryology of the Smelt I was constantly being reminded by the fishermen that the Raritan river Smelt was entirely different from that of New England, and by inquiring I found the difference to be in size, flavor, and the transparency of the skull. The fishermen maintained very strongly that the New England Smelt was a larger, coarser fish than theirs ; that in the New England Smelt no "old man's face" could be seen through the skull ; and that for the table the Raritan river fish was so much superior that there could hardly be any comparison between them. They also claimed two species of Smelt for the Raritan river : one, the common *frost-fish*—the other, the *silversides*. This latter fish, according to them, never grows to a greater length than 3 or 4 inches, and the silvery sides, and silvery reflections generally, are much *more silvery* than in the *frost-fish*. In other words, the *frost-fish* is a larger and less brilliantly tinted fish than little *Mr. Silversides*. The *frost-fish* is often found from 8 to 12 inches in length. Persons acquainted with the Raritan river Smelt, only as a table luxury, were of the same opinion as the fishermen in regard to its being a distinct species, and I was desired to investigate the subject.

In order to do this at all satisfactorily, I have found it necessary to go pretty thoroughly through the literature of the subject, both in regard to the European Smelt, (*Osmerus eperlanus*), Rond., and the American Smelt, (*O. viridescens*), Lesueur ; and in order to give a just idea of the variation, it will be necessary to follow, to a certain extent, the bibliography and natural history of the subject in this paper. I shall treat—*first*, of the American Smelt ; *second*, of the European Smelt ; *third*, compare the two ; and, *fourth*, give a fairly complete bibliography of both. While at New

Brunswick, with every day many of the Raritan river Smelt at hand, I sent to Mr. Blackford, the well-known fish-dealer of Fulton Market, New York, for some male and female Smelts, which he could guarantee me as having come from New England waters, and being genuine New England Smelt, the *O. viridescens* of Lesueur. With that kindness which he always shows towards scientific workers, he sent me some very fine fresh specimens of Smelts, which he guaranteed as having been caught in Little Narragansette Bay, R. I. With these specimens before me, placed alongside of fresh specimens from the Raritan river, I was able to compare them with the greatest nicety. There were certain slight differences. The color along the back and above the lateral line was of a slightly lighter shade of green in the New England Smelt than in that of the Raritan; the first fin-ray in each fin in the Raritan fish was darker than the rest of the fin; while in the New England fish the fins were nearly uniform in color. In length, the Raritan Smelt would probably average 5 inches; the specimens of the New England Smelt which I had, averaged about 7 inches. The Commission, however, had Raritan Smelt in their reservoir eight inches or more in length, and they have been taken in the Raritan of a length of thirteen inches, according to the fishermen. And in regard to the Northern Smelt, Mr. Ch. Lanman, in the United States Fish Commissioners' Report for 1872–3, page 224, says that the average size of Smelt in Eastern Maine and New Brunswick is only five or six inches. The shape of the body, and the length of body and head, compared with each other, in the two kinds, were nearly identical. The number of rays were the same in each, and were as follows:

B. 8; D. 11; P. 11; V. 8; A. 15; C. 19+.

The scales were the same in shape, with similar concentric markings, of proportional size and nearly transparent. Fig. 11 a, b, Pl. V. The teeth were alike, and consisted of a row of fine, closely-set teeth the entire length of the max-

illaries; one or two pairs of vomerine fangs; two rows upon the tongue, of which the anterior four or five teeth were fang-like, and generally with a single fang at the extremity of the tongue; two rows of small teeth upon the anterior portion of the mandible, of which the inner were the larger; the outer row of mandibular teeth extended laterally upon the mandibles, but were more scattered and *larger* than anterior, and also larger than those in the inner anterior row. There were also rows of palatine and pterygoid teeth, but they were all small.

All the teeth were recurved to a greater or less extent. See Fig's 8, 9 and 12, Pl. V. The viscera was similar, and the number of pyloric cæca five in each. The head in the two fish showed greater variation. In the New England Smelt it was fuller; the lower jaw did not protrude so far beyond the upper, and the gape of the mouth was not as great vertically. The difference in the fullness of the head and the rounder snout and less prominent mandible in the New England fish, are shown in Fig's 13 and 16, Pl. V. The great gape of mouth in the Raritan Smelt is shown in Fig. 9, Pl. V. The general shape of the head in the Raritan Smelt, Fig 8, Pl. V, is more delicate and pointed than in the other, Fig. 12, Pl. V; the top of the head, back from the eyes, is slightly flattened, from whence there is a rise to the dorsal contour line of the body. The delicacy of the head is due to the slight contraction of the sides of the head in the region of the eyes, Fig. 13, Pl. V, and the protrusion of the jaws thus narrowed into a more slender snout.

The lateral line in each begins at the dorsal extremity of the gill-opening, curves ventrally and posteriorly for a short distance, then passes in a straight line to the tail, near its center. The differences upon which we have, then, to form two species of them, are, *first*, a higher coloration of the back and of the first fin-rays in one than in the other; *second*, in size, and *third*, in the shape of the head. As regards the *frost-fish* and *silversides*, upon placing side by

side such specimens as were acknowledged by the fishermen to be types of the two kinds, no differences could be detected by the fishermen themselves, even in the brilliancy of the silver markings; and when convinced of this, they said, "well, these never grow any larger," referring to the *silversides*. If *size*, and perhaps a slight variation in coloration, can determine species, then we have at least *three* species of Smelt in this country.

Up to 1817, the American Smelt was considered to be identical with that of Europe. In December, 1814, Mr. Sam'l L. Mitchell read before the Literary and Philosophical Society of New York, a paper upon the fishes inhabiting the waters of the State. In 1815 this paper was published in Vol. I. of the Transactions of the Society. In this paper he says of the Smelt, page 435: "Smelt, (Salmo eperlanus,) bluish silvery salmon, with transparent head and 17 rays in the anal fin. This fish is occasionally brough to the New York market, but he is not a steady visitor.

I have eaten him in fine style at Newark, whither he was brought from the Passaic river."

In 1817, M. Lesueur in Vol. I., Journal of the Academy of Natural Science, Philadelphia, page 230, describes the American Smelt as a new species, *Osmerus viridesceus*. His description is as follows: "*Maxillaries* denticulated in their whole length; mandibles very wide and doubly carinated lengthwise in the middle; dorsal fin higher than wide, its origin corresponding with that of the ventrals; *head* and *back* of a fine golden green, as far as the lateral line; *pectorals, abdominals* and the rest of the body, silver-white; air bladder, fusiform, swoln at the middle; *body*, long, sub-compressed and sub-transparent; *back*, straight, a little elevated; *lateral line*, faint, blending the green color of the back with the white of the sides and abdomen; *lower jaw*, somewhat longer than the upper, recurved, opening prolonged as far as the eyes; teeth, strong, cylindrical, long and crooked, three at the tongue very strong, one of which

is at its extremity; *pectorals,* large; *anal,* wide in front, narrow back and slightly notched; *caudal,* forked, with acute lobes; *adipose fin,* a little bent and terminating in a point; *eyes,* orbicular, iris white and brown, pupil black; *scales* equal, rhomboidal. Length, about ten inches.

Taken with the line from Boston to Newport. Good for food. B. 8; P. 14–16; D. 11; V. 9; A. 15; C. 19^{8}_{8}.

We believe this to be a new species, and have called it *viridescens,* from the green color of its back." In February, 1818, in the 2d Volume of the American Monthly Magazine and Critical Review, New York, page 248, Mr. Mitchell says again in regard to the Smelt: " * * * * * The specimens before me were examined on March 7th, 1816, when the color of the back was pale. They were taken near New London; they are found in various other waters around New York. *It is, beyond a doubt, the Smelt of the European naturalists.* There have been no Smelts in our market for several years until now. The anal fin is regularly distinguished for possessing seventeen rays." The Italics above are mine.

In 1833, Mr. J. V. C. Smith, in his Natural History of the Fishes of Massachusetts, published at Boston, says, page 147:

"The Smelt, *O. eperlanus,* of Massachusetts, resembles that of Europe, but still there is a variation in the number of rays in the fins. At the South, there is a variety called *menidia,* which has twenty-four rays in the anal fin."

Dr. J. Richardson, Fauna Boreali Americana, London, 1836, Part III, page 185, notices M. Le Sueur's claim of a new species in the American Smelt, under the name of *O. viridescens,* but considers that, as Cuvier was well acquainted with Le Sueur's papers, and did not consider the differences sufficient to establish a new species, he will retain the name given in the Regne Animal, i. e. *eperlanus.*

He gives the rays as B. 7–8; P. 14; D. 10–0; V. 8; A. 16; C. 19^{10}_{10}; and in a note says that the last anal ray is

often divided to the base, and hence, to a cursory glance, would indicate seventeen anal rays. Mr. D. H. Storer, in his Report upon the Fishes of Massachusetts, Boston, 1839, p. 109, after describing the Smelt, says : "In the 1st Volume of the Journal of the Academy of Natural Science, of Philadelphia, Le Sueur describes this as a new species, under the name of "*viridescens.*"

Cuvier does not acknowledge this to be distinct from the European species, and therefore Artedi's name has the priority." In 1842, Mr. James De Kay, in Natural History of New York, Zoology, Part I, page 243, admits Lesueur's new species, as *O. viridescens.* He gives the length of the American Smelt at six to twelve inches ; and makes Cuvier the author of the genus *Osmerus*, instead of Artedi, to whom belongs whatever of credit there may be in the origination of this generic name. His description otherwise coincides with that of Storer. In 1845, Storer reconsidered his account of the Smelt, and in Memoirs American Academy of Arts and Sciences, New Series, Volume II, Cambridge, 1846, page 450, says : "I wrote Mr. Yarrel upon the subject, who kindly sent me several specimens of the *O. eperlanus.* Upon examination, they differ from our species, and with specimens of our own and foreign fish before me, the difference was quite perceptible. Our fish will, then, of course, bear Lesueur's name of *O. viridescens.*

Mr. Yarrel writes me, respecting the two species, 'our fish is considerably lighter in color, particularly upon the back, and on the dorsal and caudal fins. The double series of transverse lines on the sides in our fish are wider apart, and the lozenge-shaped spaces are in every sense larger. Our fish is deeper for the same length than yours ; the body is thicker, but the head, particularly the parts about the jaws, is narrower.

Our fish has the gape opening more fully vertically. The eye in our fish is smaller ; the preopercle deeper ; and its posterior edge more truly forming a vertical line.' "

Had Mr. Yarrel been describing the differences between the New England and the Raritan Smelt, he could hardly have expressed them more accurately. In Volume VI, Memoirs of same Society, p. 327, Mr. Storer adds these remarks: "The upper part of the abdomen, beneath the lateral line, presents the appearance of a satin band the entire length of the body; the upper edge of this band *is of a beautiful violet tint.* The fin rays are D. 11; P. 14: V. 9: A. 15; C. 19."

The italics above are mine.

In 1848 M. A. Valenciennes, in Histoire Naturelle Des Poissons, Par Cuvier et Valenciennes, Paris, 1848, admits the new species as the Eperlan of New York. *O. viridescens.* Lesueur. He gives the rays as follows; D. 11; A. 16; P. 12; V. 8. He says, page 283, vol. XXI,* after giving the characters which distinguish the two species, which differences are nearly as given by Yarrel, already cited, "We have received a large number of specimens of this species from the New York market, through the kindness of M. Milbert. Mitchill has considered it identical with the Eperlan of Europe, under the name of *Salmo eperlanus*, or Smelt; but one would imagine that M. Lesueur, born at Havre, and consequently at the mouth of the Seine, might have easily distinguished at the first glance a fish which he had known from childhood. The green and olive color of this species struck this naturalist, who described it in the Jour. of the Acad. of Nat. Sci. of Phil. under the name of *O. viridescens.*" In Jan., 1861, in a Catalogue of the Fishes of the Eastern Coast of North America, published as an Appendix

---

*Nous en avons reçu un grand nombre d'exemplaires du marché de New York, par les soins de M. Milbert.

Mitchill l'a confondue avec l'Eperlan d'Europe sous le nom de *Salmo eperlanus* ou de Smelt; mais on conçoit que M. Lesueur, né au Hâvre, par conséquent à l'embouchure de la Seine, ait facilement distingué à la première vue, un poisson qu'il connaissait depuis l'enfance. La couleur verte et olivâtre de cette espèce a frappe ce naturaliste, qui l'a décrite dans le Journal de l'Academie des Sciences de Phil., sous le nom d'*Osmerus viridescens*.

to the Proc. Acad. Nat. Sci. Phil., 1861, at page 53, Mr. Th. N. Gill gave the name of *mordax* to the American Smelt, without giving any reference as having described it as a new species. His only reference is Storer. Syn. Fishes N. A., page 197, where *O. viridescens* is given as its specific name. In the same volume of the Proc , page 58, Mr. Thaddeus Norris claims a new species in the Smelt of the Raritan and Delaware rivers. His description was re-printed in the American Anglers' Book, Phil., 1865, page 263.

He says: "The points of difference between this and the *O. viridescens* are, the more southern habitat of the new species, its smaller and more uniform size, and the distinct roseate purple of the streak above the lateral line. *O. viridescens*, the Northern Smelt, attains the length of twelve inches. I have seen the new species here described in quantities at New Brunswick, N. J., but never exceeding six and a half inches, exclusive of caudal." In his American Fish Culture, Philadelphia, 1868, page 202, he calls the Raritan and Delaware Smelt, *O. Sergeantti*, thus taking it for granted that it *was* a new species. In the Catalogue of Fishes, London, 1866, volume VI, pages 167–8, Dr. Guenther gives the name of *O. viridescens* to the American Smelt, and says, "Scarcely distinct from *O. eperlanus*, but with a little smaller scales; the number of transverse series above the lateral line being sixty-six. The posterior mandibular teeth not larger than the anterior ones." In the United States Fish Commission Report for 1871-2, page 810, Mr. Gill classes the Smelt as *O. mordax*, (Mitch). But Mitchill gives no such name to the Smelt. In answer to my inquiry upon this point, Mr. Gill writes to Mr. Ferguson, under date of December 9th, 1877: "The species was first described by Mitchill in the Trans. Lit. and Phil. Soc., N. Y , volume I, page 446, under the name of *Atherina mordax*. * * The species is not badly described, although, of course, Mitchill made quite a mistake in its systematic position, being deceived by a certain similarity in aspect and color between

that species and the true *Atherinæ;* the name must, however, be adopted, and the species called *Osmerus mordax.*" As Mr. Gill says, the description is not bad as applied to the Smelt, but it would apply equally as well to stray specimens of the Capelin, *Mallotus villosus,* or Argentine, *Argentina*—. DeKay Nat. Hist. of New York, 1842, Zoology, part I, page 143, says upon this point: "With regard to the *Atherina mordax,* or large Silver-sides of Mitchill, there is more difficulty," (i. e., than homologizing *A. viridescens* with *A. menidia*). "From its dental armature and adipose dorsal, it cannot be arranged in this family. In his "report in part," he states that 'it may be *A. Brownii;* if it be so considered, we shall know it better for the future.' I am not acquainted with the species referred to, but have no doubt that the *mordax* is the true *Osmerus* of the family *Salmonidea.* I am disposed to believe that my late venerable friend has, by mistake, applied the description of *O. eperlanus* this species," (*A. menidia*).

If, therefore, a person does a thing when he does not intend it at all, that thing must be binding upon all who come after him. And because Mr. Mitchill wrote a description of *some kind* of a fish, and attached the specific name of *mordax* to it, therefore, because *that kind* of fish is not known exactly, and because the description applies fairly to the Smelt, the Smelt must be known as *mordax.* Mr. DeKay did not think so; Mr. Guenther did not think so; accordingly, neither of them have given to the Smelt the synonym of *mordax.*

But what is much more to the point and certain, is that Mitchill did not intend this description to apply to the American Smelt. He was acquainted with the Smelt, and in this same report, upon a previous page, (435,) he describes it as *Salmo eperlanus;* and again, at a later date, February, 1818, in American Monthly Magazine and Critical Review, page 248, he says: "It is, beyond a doubt, *the Smelt of the European naturalists.*" We can, then, adopt

one of three methods of settling the question : to consider, as with De Kay, that it was a mistake in describing a spemen of *A. menidia;* that it was a stray female Capelin, or a strange form of Argentine ; or that it was some fish which we cannot identify. To whichever conclusion we may arrive, it is equally evident that Mr. Mitchill did not intend that the American Smelt should be erected into a new species ; hence, *mordax* ought not to be used in connection with it. I hardly think that the scientific claim for priority in nomenclature has arrived, as yet, at that pass that things not intended, and not desired, shall become *faits accomplis.*

The change in synonymy of the American Smelt, up to present time, has been, *Salmo eperlanus,* Mitchill ; *Osmerus eperlanus*, Smith ; *O. viridescens*, Lesueur ; *O. mordax*, Gill ; *O. Sergeantti*, Norris. Mr. Lesueur made a species of the American Smelt as distinct from the European, almost solely upon a difference in *color*.

Mr. Norris made a species of the Raritan and Delaware Smelt, upon *color* and *size*. Now, to please the fishermen, we ought to create a new species, on account of *size*, to indicate their little *Mr. Silversides*. We will then have, on the eastern coast of the United States, *O. viridescens*, Lesueur, for the northern fish ; *O. Sergeantti*, Norris, and *O. argenteus*, Rice, for the southern fish. But it is best to bear in mind that in the Smelt we find a range of color from light green to dark green upon the back, and dull or more polished silvery-sides, with or without a roseate tint on or above the lateral line ; in length, a range from fry up to ten or twelve inches ; in rays, B. 7–8 ; D. 10–11 ; P. 11–16 ; V. 8–9 ; A. 15–17 ; C. 19+. And these ranges occur in fish from each and every place which claims a new or different species.

European Smelt.

The Smelt of Europe was known very early in France as the Eperlan. To this name Rondeletius or Rondelet gave a Latin termination, calling it *eperlanus*

Willoughby named it *Eperlanus Rondeletii*.

Gronovius changed its generic termination by putting it among the *Salmonidæ*, in the genus *Salmo*. And Linnæus transferred Willoughby's generic term, and attached it to the generic name of Gronovius, and the Smelt became known to scientific persons, for a long time, as *Salmo eperlanus*. Artedi then instituted the genus *Osmerus*, and Lacepede placed the Smelt in this genus, as *O eperlanus*, which name it holds up to the present time. Scientifically, the name would be *Osmerus*, (Artedi), *eperlanus*, (Rondel.), Lacepede. Other names have been given it by persons who supposed they were describing new species of Smelts; these will appear in the bibliography. A very excellent description of the European Smelt, or Eperlan, was given by M. Marc Elieser Bloch in his Ichtyologie, Berlin, 1785.

Very little has been added to the description of the Eperlan since then, except to show that Bloch's two species were but old and young of the same form. I give his description, and it may be well to compare it carefully with the descriptions already given of the American forms. I quote from Castel's edition of Bloch, Paris, 1809, Volume VI, page 29.*

---

* L'Eperlan, *Salmo eperlanus*.

On reconnoît ce poisson à sa mâchoire inférieure qui est avancée, et aux dix-sept rayons de la nageoire de l'anus. On trouve sept rayons a la membrane des ouies, onze aux nageoires de la poitrine, huit à celle du ventre, dix-neuf à celle de la queue, et onze a celle du dos.

L. Eperlan a le corps demi-transparent; il brille d'un vif éclat, et presente successivement le vert, le bleu et le blanc dont il est orné. Le corps est rond, et devient plus mince en avançant vers la queue et vers la tête; de sorte qu'il ressemble assez à un fuseau. La tête est petite, et finit en pointe émoussée. Les yeux sont grands et ronds, la prunelle noire, et l'iris argen-

" The Eperlan, *Salmo Eperlanus.*

This little fish may be recognized by its protruding mandible and the seventeen rays in its anal fin. The other rays are B. 7 ; P. 11 ; V. 8 ; D. 11 ; C. 19.

The Eperlan has a semi-transparent body, which shines with great brilliancy, and presents successively tints of green, blue and white, with which it is adorned. The body is round, and becomes smaller towards the head and the tail, so that it quite resembles a spindle. The head is small, and ends bluntly. The eyes are large and round ; the pupil black, and the iris silvery, shading into blue. The lower jaw is recurved ; the upper straight. Both are, as well as the palate, provided with small inwardly curving teeth. Four or five teeth are also found upon the tongue. Its body, which is generally only two or three inches long, is covered with small silvery scales, which are easily detached. This fish is so transparent, that one can distinguish in the head the divisions of the brain, and count in the body the vertebræ and the ribs. The back is round and gray ; upon the sides there is a silvery depth, upon which one sees a changeful mingling of green and blue tints. The belly is round

---

tin tirant sur le bleu. La mâchoire inférieure est recourbée ; la supérieure est droite. Toutes deux sont, ainsi que le palais, pourvues de petites dents recourbées en dedans. On voit aussi quatre à cinq dents sur la lange. Son corps, qui n'a pas ordinairement plus de deux on trois pouces de long, est convert d'écailles minces, argentines, qui se détachent aisément.

Ce poisson est si transparent, qu'on peut distinguer dans la tête les parties du cerveau, et compter dans le corps les vertébres et les côtes. Le dos est rond et gris ; sur les côtes, il a un fond argentine, sur lequel on voit une couleur changeante vert et bleu, ce qui forme un mélange changeant. Le ventre est rond, blanc tirant sur le rouge. Si la couleur qu'il offre aux yeux est agréable, l'odeur que son corps exhale ne l'est point du tout. Toutes les nageoires sont grises ; celle de la queue est fourchue. La nageoire adipeuse est placée vis-à-vis de la nageoire de l'anus, et la dorsale est au milieu du corps. * * * Comme la chair de ce poisson n'est pas facile à digérer, on ne sauroit en conseiller l'usage aux personnes foibles et valétudinaires.

and white, shading into red. If the color which it offers to the eye is agreeable, the odor which its body exhales is not so at all. All the fins are gray ; that of the tail is forked. The adipose fin is placed opposite the anal, and the dorsal is in the middle of the body." He adds, a little further on, "as the flesh of this fish is not easy to digest, one should not advise its use to feeble persons or valetudinarians." He considers this a fresh water fish, and separated it from the sea Eperlan, on account of the latter being a sea fish ; its larger size, being from ten to twelve inches in length; and its stronger odor. They have since been found to be but young and old of the same species.

In Rees' Cyclopædia, 1st American Edition, Vol. XXXII, Article Salmo, B. *eperlanus*, we find : "Of this species there appears to be two varieties, one not exceeding the length of three or four inches; the other arriving at the general length of six, eight, and sometimes even to twelve or thirteen inches. * * * The skin is thin, and the whole body—but particularly the head—is semi-transparent ; the color of the back is whitish, with a cast of green, beneath which it is varied with blue, and then succeeds the beautiful silvery gloss of the abdomen. * * In front of the upper jaw are four large teeth." M. Valenciennes, in Histoire Naturelle Des Poissons, Par Cuvier et Valenciennes, Paris, 1848, Tome XXI, page 272, gives the rays as follows: B. 8 ; D. 11 ; A. 16 ; V. 8 ; P. 11 ; C. 25.

At page 279, he adds :† "The color of the Eperlan varies according to the depth. Noel de la Moriniere has already indicated these variations in color in his little Treatise upon

---

† La couleur des Eperlans varie suivant les fonds. Noel de la Morinière a déjà indiqué ces variétés de couleur dans son petit "Traité sur l'Eperlan." Les pêcheurs distinguent l'Eperlan blanc et le vert.

La chair de ceux-ci est maigre et de mauvais goût ; cependent, l'Eperlan vert du Pont-de-l'Arche est d'une excellente qualité.

the Eperlan. Fishermen distinguish the white and the green Eperlan. The flesh of the white is poor and of bad taste, but the green Eperlan of the Pont-de-l'Arche is of excellent quality."

Mr. Yarrel, in the British Fishes, London, 1859, Volume I, page 298, gives the rays as, D. 11 ; P. 11 ; V. 8 ; A. 15 ; C. 19.

He gives the color of the upper part of the body as, "pale ash-green ; all the lower parts, cheeks and gill-covers, brilliant silvery-white." The forms of the European Smelt, which at one time were considered to represent separate species, have thus been united into a single species, *O. eperlanus*, with a range of color, from white or light ash to green, upon the back ; more or less brilliantly silvered sides and abdomen ; with or without more or less of a blue or roseate blending at or above the lateral line ; rays, B. 7–8 ; D. 11 ; P. 11 ; V. 8 ; A. 15–17 ; C. 19–25 ; length, fry to thirteen inches. If we add to the rays those of the fish described by Richardson, Fauna Boreali Americana, Part III, page 185, which is as likely to be a European as an American form, we will have the range of rays : B. 7–8 ; D. 10–11 ; P. 11–14 ; V. 8 ; A. 15–17 ; C. 19–25.

If the European forms, representing such ranges in color, rays and size, are to be considered but a single species, it is no more than right that the American forms, with almost identical ranges of color, rays and size, should also be considered but a single species, and that the differences in the head, already noticed, are due to local causes, and are of not enough importance to form specific features.

But in contrasting these ranges in the European and American forms, we are led to the conclusion that unless there are greater differences than geographical differentiations, such as have formed the varieties in the European and American fishes, they should both be considered but one species. A difference in coloration ought not to separate them, and if the chief difference is in the foreign fish having

narrower jaws and a mouth capable of farther vertical distention than our own northern form, as Mr. Yarrel claims, surely the Raritan Smelt ought to fill the bill in every particular.

Guenther, Cat. Fishes, VI, pages 167-8, has summed up the differences, and all that can be given scientifically, when he says, already quoted, "scarcely distinct from *O. eperlanus*, but with a little smaller scales ; the number of transverse series above the lateral line being sixty-six. The posterior mandibular teeth *not* larger than the anterior ones." He makes the number of transverse series in the European Smelt 60-62, and says that the posterior mandibular teeth are larger than the anterior ones. I have had an opportunity of examining six specimens of Smelts from the Liverpool Free Museum, genuine *O. eperlani;* and also Smelts from all along the Eastern Coast of the United States.

I find that in specimens of *equal size* of the two forms, the scales from the same positions upon the body are either of the same *shape* and *size*, or a trifle larger in the *American fish.* The teeth are identical, and in both fish the *posterior mandibular teeth are scattered, and larger than the anterior ones.*

The transverse series I find to be as follows, in specimens from different parts of our coast, and in those from Liverpool :

	American forms.	Liverpool.
Eastport,	65	65
Lake Champlain,	65	64
Portland,	64	64
Woods Hole,	66	63
Raritan River,	62	62
Chesapeake Bay,	62	62

The fin rays in the specimens from Liverpool were D. 9 ; P. 11 ; V. 8 ; A. 15 ; C. 19.

In fact, the two forms were so similar in general appearance that if taken from the same basket they could hardly fail of being declared the same fish.

I have thus hastily and incompletely compared the two fishes, and have endeavored to give in Fig, 8, Pl. V. an accurate representation, excepting the scale series, of the Raritan river form of the Smelt.

I can arrive at no other conclusion, from seeing and examining both forms, and from knowing the differences which geographical distribution brings about, than that arrived at by Mitchill in 1818. "It is beyond a doubt *the* Smelt of the European naturalists." To it then justly belongs the name of *Osmerus* (Artedi) *eperlanus*, (Rondelet), Lacepede. I have accordingly given it this name in the preceding papers. If it is ever necessary to designate the two forms, the American form can be called *O. eperlanus var. viridescens.*

SYNONYMY OF THE ATLANTIC SMELT.

(Osmerus eperlanus).

A. European Form.

Eperlanus—Rondelet, Pars. II, page 196 ; Belon, De Aquat. page 288 ; Gesner, Aquat. page 362, Thierb. page 189; Aldrov. IV, c. 12, page 536 ; Jonston, II, c. 2, t. 24, f. 3 ; Charlet Onom. page 153, n. 3 ; Ray, Synop. page 66, n, 14.

Eper. Rondeletii—Willoughby, page 202, tab. N. 6, f. 4.

Spirinchus—Jonston, t. 47, f. 6 ; Schonov. page 70, tab. 7.

Salmo, sp.—Gronovius, Zoophy, page 122, n. 373, Mus. I. page 18, n. 49.

Salmo eperlanus—Linn. Sys. Nat. 1, page 511 ; Ruysch. Theat. page 78, tab. 24, figure 3 ; Bloch. 1, page 179, taf. 28, figure 2 ; Bl. Schu.

page 410 ; Donov. Brit. Fish. II, pl. 48 ; Turton, B. Fauna, page 104 ; Pall. Zoog. Ross. As. III, page 386 ; Gronov. Sys. ed. Gray, page 152.

Salmo eperlanus var. marinus—Walb. Artedi, III, page 57.

Salmo eperlano-marinus—Bloch. Ber. 1785, 1, page 128, taf. 28. f. 1.

Salmo albula—Wulff. Ichth. page 37, n. 47.

Salmo albula and eperlanus—Zueck. Mat. Alim., page 262.

Trutta, sp.—Klein, Pisc. Miss. V, page 20, n. 12, tab. 4, figures 2-4.

Osmerus, No. 1—Artedi, Gen., page 10, n. 1, Syn., page 21, n. 1 ; Spec., page 45.

Osmerus eperlanus—Lacep. V., page 229 ; Rich. F. B. A., 1836, III, page 185 ; Flem. Brit. An., page 181 ; Jenyns, Man., page 429 ; Yarrel, 2d ed. 1859, II, page 129 ; 3d ed. I, page 295 ; Cuv. et Val. 1848, XXI, page 270, pl. 620 ; Guenth. Cat. Fish. '66, VI, page 166.

S. (O). spirinchus—Pall. ——— page 387.

O. spirinchus—Cuv. et Val. XXI, page 281.

O. microdon—Cuv. et Val. XXI, page 280, pl. 621.

E. vulgaris—Gaimard, Voy. Isl. and Grœnl. Poiss., pl. 18, f. 2.

B. American Form.

Salmo eperlanus—Mitchill, Trans. Lit. and Phil. Soc. N.Y. 1815, I, page 435, Amer. Mon. Mag. and Crit. Review, New York, 1818, II, page 248.

Osmerus eperlanus—Smith. Nat. Hist. Fish. of Mass., 1833, page 147 ; Rich. Faun. Bo. Am. 1836, III, page 185 ; Storer. Fish. Mass. 1839, page 109.

Osmerus viridescens—Lesueur, Jour. Acad. Nat. Sci. Phil. 1817, 1, page 230; DeKay, Nat. Hist. New York, Zoology, Part I, page 243, Pl. 143; Storer, Mem. Amer. Acad. of Arts and Sci., new series, 1846, II, page 450, 1857, VI, page 327; Cuv. et Val. Hist. des Poiss. 1848, XXI, page 283; Jordan and Van Vleck, Pop. Key, 1874, page 83.

Osmerus, sp.—Norris, Proc. Acad. Nat. Sci. Phil. 1861, page 58, Amer. Anglers' Book, Phil. 1865, page 263, Fig.

Osmerus Sergeantti—Norris, Amer. Fish Culture, Phil 1868, page 202.

Osmerus mordax—Gill, Proc. Acad. Nat. Sci. Phil. 1861, Appen. page 53, U. S. Fish. Com'r's Rep. 1871-2, page 810; Md. Fish Com. Report, 1877; Jordan, Manual of Vertebrates, 1876, page 261.

Very respectfully,

H. J. RICE.

NOTES

UPON THE

DEVELOPMENT OF THE SHAD.

Alosa Sapidissima (?).

H. J. RICE, B. Sc. CORNELL,

Fellow in Nat. Hist. Johns Hopkins Univ.

MR. T. B. FERGUSON,

Commissioner of Fisheries State of Maryland.

SIR :—The headquarters of the Commission, for the purpose of hatching Shad spawn, had been established (May, 1877) in Carrot cove, on the Northeast river, just across the flats, east from the village of Havre de Grace, Maryland. The headquarters consisted of two large covered barges, one of which served as a lodging house for the men employed by the Commission in manipulating the spawn ; the other as an engine house, to contain the machinery used in working the hatching apparatus.

This hatching apparatus consisted of a series of cylindrical sheet-iron buckets, with wire seive bottoms, attached to arms worked vertically by an engine situated within the barge. The arms were in sets, one upon each side of the barge, and extended out from the sides of the barge and over the water, about three and one-half feet. The buckets were attached to stringers, connecting the over-hanging arms, in one or two rows on each side the barge, and as close together as they could be conveniently fastened. They were so placed that when the arms were raised to their highest point the

bottoms of the buckets would be eight or nine inches below the surface of the water. This apparatus is for use in quiet water, or where there is not sufficient current in the water to move the eggs in the ordinary floating boxes. In other words, it enables the shad-hatcher to prosecute his work quite independent of wind, wave, current and weather, and hatch his spawn at all times during the spawning season. He is not obliged to seek a current, but can make a current for himself. Shad eggs are very light, and for their best care it seems to be necessary to keep them in motion while hatching. When they are placed in the buckets, and the arms worked by the engine, thus alternately raising and lowering the buckets, a current is produced through the seive portion by the buckets, which keeps the eggs constantly in commotion. The men attached to the Commission went each evening to the different fisheries along the shore of the bay, and gathered the spawn and milt from the ripe Shad, as they were taken by the fishermen from the seines. The spawn was manipulated very much, as already described for the Smelt. It was then brought, in the pans in which it was collected, for some times three or four miles, and often over quite rough water, and deposited in the apparatus just described. Generally, all the apparatus was filled with spawn in different stages of development. These buckets were the reservoirs from which I drew my working material. It will be seen, that from the hundreds of thousands of eggs and young fry thus presented, a fine selection could be made for study. This was the case with the exception of specimens representing the changes which take place during the first hour or two, or while the eggs were being brought from the fisheries to the hatching dishes.

Of these changes I was able to get specimens at South Hadley Falls, Massachusetts, in July, at the Hatching Camp of the United States Fish Commission, through the kindness of Deputy United States Commissioner of Fisheries, James W. Milner.

A room in the sleeping barge was kindly allotted to my use. This was very soon converted into a miniature scientific laboratory, and here each lot of ova or fry was taken, examined under the microscope, drawings made of the different stages, and then the specimens were placed in picric, osmic, or chromic acid—sometimes the same age specimens were put in all three—to harden, for the purpose of cutting sections, and thus authenticating the work. The specimens were manipulated under the microscope the same as those of the Smelt, page 57, and the same oculars and objectives used.

Shad eggs are exceedingly adaptable to the use of the embryologist, on account of their convenient size and great transparency. After "rising" they become about one-eight of an inch, more or less, in diameter, and very much like round clear crystals. Impregnation seems to take away even that opaqueness which existed in the freshly laid egg, and what is of much more importance, the vitelline membrane does not become opaque afterwards, so that every process can be seen with the greatest distinctness.

Unimpregnated Ovum.

The ovum freshly taken from the Shad consists of a vitellus, composed of innumerable large and small oil globules, embodied in or surrounded by a matrix of granular, somewhat opaque, plasma, enclosed by a delicate, nearly hyaline, membrane, which at first closely embraces the vitellus, and which is folded and wrinkled in all directions. Fig. 1, Pl. VI. In the great majority of the unimpregnated ova, this vitelline membrane remains wrinkled and folded closely about the vitellus, and even when placed in water, the absorption is so slight that the membrane is barely raised from the periphery of the vitellus, and very few of the foldings become obliterated. In some, the absorption is partial, Fig.

2, Pl. VI; and in about ten per cent,* or less, of unimpregnated ova, the absorption of water is complete, and the vitelline membrane becomes completely distended. The increase in diameter of the ova by this absorption of water, and distention of the membrane, is about one-half of the fully distended ova, in some cases not quite as much as this. Shortly after the distention of the vitelline membrane, and sometimes, even when the ovum is as represented in Fig. 2, Pl. VI, the vitellus, which is floating free in the centre of the ovum, becomes changed somewhat upon one side. A gathering together of the oil-globules upon this side, and a change of their form takes place. The globules are drawn out into somewhat pear-shaped bodies, with the smaller ends directed towards a common centre, Fig. 3, Pl. VI, and over this common centre a prominence, or limb, arises, which protrudes for quite a little distance from the vitellus, Fig. 5, Pl. VI.

This limb is composed almost entirely of granular substance, with a few small oil-globules in the base, and is a shade or two less translucent than the rest of the vitellus, having acquired apparently a tint of brownish yellow. In those ova which *remain* only partially distended, no limb is formed. The contour line of the vitellus is unbroken during this entire period, or at any other period during the life of the ovum, by any glomeration from the surface or the production of any direction cells from the blastoderm. The ovum will often remain in this stage of differentiation for a day or

*Mr. C. G. Atkins, who was in attendance at the Hatching Camp of the United States Fish Commission, at South Hadley Falls, Massachusetts, during the past summer, sends me the following schedule of observations made by him upon this point :

Date.		No. of Eggs.	No. swollen.	Percentage.
July	11	306	6	.02
"	19	300	35	.11
"	31	103	9	.09
August	10	small number	0	.00

more, when it becomes gradually opaque and disintegrates. During this period of disintegration, masses, larger or smaller, will protrude from the surface of the vitellus, and oftentimes of very fantastic shape, Fig. 10, Pl. VI. The remainder of the vitellus, during this early limbed condition, remains very much as in those ova which show no "rising" phase; i. e., with oil-globules scattered throughout a granular matrix. The unimpregnated ova which do not swell at all, and those which partially swell, but in which no "limb" is formed, disintegrate much more rapidly than those which pass through the "limbed" condition. In their disintegration there is a certain amount of glomeration, but this is not as distinct as in the others, on account of the closely investing vitelline membrane. The vitelline membrane has no micropyle, and is *apparently* without pores.

Impregnated Ovum.

The most noticeable difference, to the eye, between a pan of impregnated and one of unimpregnated ova, is in the very much greater proportion of swollen eggs in the pan to which milt has been added. This is not so noticeable, unless the impregnation has been performed by the dry method. This has a certain limit, to be sure, since the eggs are quite a little time in absorbing water, and if the ova are placed in water as soon as stripped from the fish, and within half a minute afterward the milt is added, the result will be pretty satisfactory. But the best results will be reached when the ova and milt are placed in the water simultaneously. The first changes which take place in the impregnated ova are similar to those already described in the swollen unimpregnated egg. First, a slight swelling out or distension of the vitelline membrane; then, while the distension proceeds, a gathering together of the globules to one side of the vitellus, and a drawing up of the granular plasma into a "limb" or blastodermic protuberance. Figs.

2, 3 and 5, Pl. VI. This protuberance is longer in one direction than in the other, its outline marking an oval upon the surface of the vitellus. Soon, at the shorter diameter of the "limb," a very slight line of crinkling of the tissue can be seen upon the surface, extending from one side to the other, Fig. 4, Pl. VI. The crinkled appearance very soon passes away, and the tissue beneath becomes depressed into a sharply defined groove, which extends to near the base of the "limb," and divides it into two nearly equal hemispherical lobes, Fig. 6, Pl. VI.

As soon as the groove, or segmentation furrow, has attained its greatest depth, it begins to close again, until it is only about half its former depth, in which condition it remains.

A second faint line of crinkling of the tissue can now be seen along the centre of the "limb" at right angles to the first segmentation furrow, Fig. 6, Pl. VI.

This crinkling appearance soon disappears, as in the first case, and a second segmentation furrow is formed, dividing the "limb" into four rather obtuse papillæ. From this time forward there is no regularity in the number of the segmentation furrows, or in the segmentation of the papillæ upon different portions of the "limb." Sometimes, one of the four segmental papillæ already formed will divide and form two complete papillæ, before there are any signs of division in the remaining three. We thus have a form with an odd number of papillæ, Fig. 7, Pl. VI. Sometimes this segmentation will extend to one pair of papillæ, and after they are segmented and nearly ready to segment a second time, the other pair or pairs will segment. Although the segmentation, as thus seen, is not a regular system of bilateral coincident divisions of the four original papillæ, and of the new divisions in their turn, since an odd number of divisions is perhaps as often seen as an even number, yet this segmentation is always accompanied by the faint crinkling line of depression in the tissue; the disappearance of

the crinkled marking; the deepening of the depression, and consequent complete division of the parts; and the partial filling up of the furrow before a new one is formed. The segmentation continues in this irregular way, until the entire "limb" has become transformed into a great number of small rounded prominences upon one side of the vitellus. The ovum is now in what is known as the "mulberry" stage, Fig. 8, Pl. VI.

Segmentation does not stop here, but continues until the side of the ovum upon which the limb was situated, has assumed nearly its original granular appearance, and is a little darker in color, because denser than the rest of the vitellus. The segmentation also extends outward from this granular portion, and affects the contiguous peripheral portion of the vitellus, until we find the blastoderm, as this portion can now very properly be called, occupying quite a good portion of the moiety of the surface of the vitellus. The segmentation has taken place more in one axis than in the other, and so we find the blastoderm oval in outline, but very much more so in proportion than was the original "limb." A depression now takes place along the longer axis of the blastoderm, Fig. 9, Pl. VI, until the blastoderm is divided into two nearly equal parts, much as was the "limb" at first, except that these last divisions do not form semi-circular, but very long, oval lobes. These lobes become thinner along the periphery, and are gradually transformed into the laminæ, which, by their folding inward and union along the median line, form the neural canal, already mentioned in connection with the Smelt, page 63. The union of the laminæ along the entire median line takes place very soon in the Shad.

The outlines of the enclosed neural canal are plainly visible, making a complete circuit of the embryo.

At one end of the canal three expansions take place, which are the three cerebral vesicles, and along the middle of the embryo two or three pairs of proto-vertabræ are seen

forming from the sides of the canal. The canal is lined throughout by a layer of exoderm, which has been folded in by the closing of the laminæ, and by the differentiation of the portions of exoderm forming the three cerebral vesicles the brain is formed, and by the differentiation of the exoderm lining the rest of the canal, the spinal cord is formed. The further transformations in the Shad are similar, with the exception of the time occupied in the transformations, to those of the embryo Smelt, which have already been described, so I will proceed no further in describing the embryology of the Shad, except to give the time at which the different transformations take place. Within half an hour after being placed in water the ova are fully distended, and within an hour the great majority of them have passed through the various stages up to that figured in Fig. 6, Pl. VI, where the "limb" is completely divided by the first segmentation furrow into two nearly equal protuberances. During the next hour or two the segmentation progresses until the "limb" has become divided into quite a number of prominent papillæ. In about four hours it has reached the "mulberry" stage; and in five to six hours the lamellæ stage, represented in Fig. 9, Pl. VI, is reached. At ten hours the laminæ have united, and the embryo appears as a darkish band, streaking the longer axis of the blastoderm. At twelve hours the head end is indicated by becoming slightly broader than the other. At fifteen hours the cerebral vesicles, and a few pairs of proto-vertabræ, can be seen. At sixteen to eighteen hours the proto-vertabræ are quite numerous, and the eyes are indicated by circular markings on the lateral walls of the middle cerebral vesicle. In twenty two hours the brain is quite plainly outlined; the ear has become depressed; the exoderm is pressing in the eye sack to form the crystalline lens; the nasal pouch is indicated by a round disk-like marking; and a tract of tissue material in the anterior region, between the embryo and yolk, intimates the heart. At twenty-three hours the crystalline lens is more

enclosed; the proto-vertabræ numerous and distinct; and the heart tubular, and beginning to pulsate. At thirty-eight hours the cerebellic fold of the brain is very distinct; the crystalline lens has become completely enclosed, but the eye, as yet, has acquired no pigment granules; the ear is beginning to close; and the branchial fissures are forming. At sixty-two hours the mouth has opened; the semi-circular canals of the ear have formed, and the ear has closed externally; and the pectoral fins have formed to a certain extent. About this time, or during the third day, the young fry begin to hatch from the ova. At sixty-nine hours the visceral arches are formed, but with no vessels in them; the operculum is growing backward, toward and over the first arch; the pectoral fins are quite prominent; and the heart has become a bi-lobed affair, with the two lobes nearly in the same horizontal plane, the auricle on the left side of the embryo, the ventricle on the right, and the only evidence now of a cavity is a small connecting vacuole in the centre of their abutting sides. At eighty-eight hours everything is more mature; the yolk-sack is somewhat absorbed; and the heart has assumed its mature position, with the auricle upon the dorsal side of the ventricle. During the fourth day the first circulation, through the first and second branchial aortæ, is established; and during the fifth day vessels are formed, and blood flows through all the visceral arches. By the seventh or eighth days the vessels in the body are formed, and we have a complete systemic circulation. In speaking of the omphalo-meseraic arteries, page 75, I mentioned the Shad as having only one. This is perhaps not strictly true, since the large artery which is given off above the vitellus passes along the upper side of the intestine, returns along its lower side, passes along the dorsal side of the yolk, without giving off any branches to it, and goes directly to the heart. Although it is not what an omphalo-meseraic artery is generally considered to be, that is, one which sends ramifying branches over the entire surface of the yolk, yet it, without

doubt, performs the functions of such an artery by abstracting the food-material from the yolk in passing over it; the food-materials undoubtedly being drawn for this purpose, by osmosis from cell to cell, into the upper portion of the yolk, and in contact with the vessel. The unimpregnated ova are not by any means the only ones which disintegrate and die. Too many, by far, of the impregnated ova are guilty of the same performance, and exhibit in their disintegration all those curious irregular phases, one of which is represented in Fig. 10, Pl. VI. Sometimes, instead of there being a great many ball-like protrusions, there is a single round ball, nearly as large as the vitellus; the vitellus and the ball looking very much like the two ends of a large dumb-bell, without any connecting handle. Oftentimes, after the embryo has progressed quite a little in its development, one or both ends will turn opaque, and gradually disintegrate. Sometimes ball-like protrusions proceed from the disintegrating portions, sometimes the disintegrating portions form floculent masses, floating out from the vitellus towards the vitelline membrane.

I have said that at Carrot cove, in the Chesapeake bay, the spawn was often brought for three or four miles across the bay, and often over very rough water. The rolling and pitching of the boat upon the waves, and the consequent knocking together of the ova, without doubt, had a very injurious effect upon them. If the ova in the boxes are subjected to a severe storm, or if the ova are roughly pressed upon, in manipulating them, the loss is much greater than with ova treated very gently, and kept in a steady, yet not violent, current of water, away from the reach of boisterous waves and severe rains.

If rough handling and severe peltings will injure the ova, why will not rolling and tumbling in a boat over a stormy sea? It is very possible, if not highly probable, that this cartage in boats, particularly in rough water, may be the chief cause of this disintegration in the advanced as well as

the freshly spawned ova. It is also highly probable that the methods of manipulation may have much to do with it. Often quite a time elapses, especially when following the gill nets, between the spawning of the ova and the shedding of the milt upon them. At such times the manipulation must almost necessarily be imperfect. It is, therefore, very questionable whether it would not be better upon the whole to carry all ripe fish from the nets, especially the gill-nets, to the hatching barges, before spawning or milting. This might involve the purchase of a large number of fish, but if by this means the irregular results, which so often follow the cartage of the spawn, could be avoided, and the number of young fry hatched from the ova be relied upon as being from ninety-five to ninety-eight per cent. of the whole amount of ova, instead of as now varying from fifty up to one hundred per cent., it would be much more profitable. Once at the hatching-house, the spawn could be taken care of in the most approved manner, and records kept, which would enable one to work with much more assurance that the irregularities would be eliminated. It has been by the patient and gradual working out of those things unfavorable to the development of Shad ova, that Shad hatching owes its present success. It took a longer time to attain comparative success with the Shad than with the Trout, &c., on account of the delicacy and lightness of the Shad ova; and if the Commission can, at some expense and a little pains, do away with the irregularity in the percentage of hatched fry, and yet hold to their other methods, they will have added just so much towards the literature of the Shad Hatchers' Manual, and their own success as Shad propagators.

The remaining subject to be spoken of is in regard to the temperature of the water. The development mentioned in this paper took place in water of a temperature from seventy-three to seventy-six degrees. In water of such a temperature the young Shad will, as already mentioned, hatch out during the third day. If the temperature of the water be

increased four or five degrees, or to about eighty degrees, the young fish will hatch out in about forty-eight hours. This holds good for spawn *taken* when the water is about seventy-four or seventy-five degrees in temperature. But when the water gets so warm that its mean temperature is eighty degrees or over, we begin to find the female Shad full of what is called "rotten spawn," with which nothing can be done. The warm water seems to have the effect of killing the spawn in the ovaries of the female, before she has reached her spawning ground on her journey from the sea. Consequently, in Shad working, the run of fish during such warm spells are worthless, so far as propagation is concerned, and the Shad-hatcher has to wait until the water moderates in temperature, and a new immigration of Shad, fresh run from the colder water of the ocean, takes place. The only alternative, to waiting for these spells of warm water temperature to pass, and for the influx of new schools of Shad, is to begin operations earlier in the season ; take such females as have matured early ; be a little longer in hatching out the young fry, getting by this means a hardier lot, of course ; and extending operations until the increase in temperature of the water brings the females which have bad spawn.

Very respectfully,

H. J. RICE.

ADDITION

TO

LIST OF FISHES

OF MARYLAND,

PREVIOUSLY PUBLISHED.

See Reports, January 1st, 1876, and January, 1877.

EXPLANATIONS AND ABBREVIATIONS.

ACAD. COLLECTION signifies that specimens are in the Maryland Academy of Sciences.

FINS.—D. Dorsal, *i. e.*, on the back; sometimes two in number.

P. Pectoral; attached behind the gill-covers.

V. Ventral; attached to the lower side in front.

A. Anal; attached to the belly near the vent.

C. Caudal; the tail fin.

Baltimore, January 1st, 1878.

Maj. T. B. Ferguson,

Commissioner of Fisheries of Maryland:

Dear Sir:

During my last visit to the sea-coast of Worcester county, Md , to obtain specimens of fish for the Maryland Academy of Sciences and the Museum of Druid Hill Park, I had the pleasure to observe a "run" of Blue-fish (*Pomatomus saltatrix*). Those that go to the sea-side towards the end of October for the purpose of shooting the numerous different kinds of water-fowls, have probably seen this phenomenon, and will pronounce it a sight well worth seeing, and one not easily forgotten by the lover of nature.

Towards the middle of October the fishermen have engaged an extra crew, and have all the seines ready to be used on short notice. The northern horizon is closely watched for indications of this precious fish; one, and the most noticeable, of which is the presence of large numbers of the different kinds of gulls that hover over the fish, moving southward. Instead of following their usual mode of flight, the sea-gulls gather in compact masses over the fish, darting down continuously and striking at their prey. About the middle of the month the seines are thrown out, to make a trial for Blue-fish; but only the smaller sizes, varying from eight to twelve inches, are caught. They are fish that had remained in the neighborhood through the summer. At last, the desired moment arrives. Far away northward the ocean has changed its usual aspect, and it is evident that large shoals of fish are moving towards the station. Every one rushes to the boat, and the long seines are soon in position. The fish come nearer and nearer, much too slowly, however, for the old fishermen yonder, whom old age has prevented from entering the boat. He looks at the moving shoals in a rather suspicious manner; the excitement his face showed but a few moments ago gradually disappears; an expression of extreme disgust only too plainly takes its place, and with a vigorous kick in the yielding sand, he

turns around, expressing himself with an emphasis and clearness more forcible than polite: "*Old Wifes.*" Yes, those living masses of fishes are nothing but the Ale-wifes (*Dorosoma cepedianum*). Though of considerable value on account of their large size, they are certainly not the long-expected game, and are, therefore, not molested. These so-called "Eastern Ale-wifes," thus named because they attained their full growth along the coasts of the New England States, are now migrating southwards, and are the sure fore-runner of the Blue-fish. At last they come; the whole water is boiling and foaming with them, as they advance. Sea-trouts, Old-wifes, and other fish, in their anxiety to escape their merciless foes, run entirely out of the water, covering the whole beach with their shining and quivering bodies. Unable to reach their native element again, they die in uncounted numbers—many of them more or less mutilated by their cruel pursuers, some having lost their tail, others their head, and others the half of their bodies.

In a few short hours, sometimes even much less, one "run" of Blue-fish has passed. Others follow in shorter or longer intervals, and if they do not escape unnoticed during the night, or are not too far away from the shore to be seen by the fishermen, these people harvest a well-paying crop, though a very laborious one to gather. October 17th, October 25th, November 7th, are the dates on which, during the last three years, the first "run" of Blue-fish passed Ocean City. The average weight of one of these fish is about 14 lbs.

Many forms of fish were obtained during these trips; most of them were well-known species, already in the collection; others were known to occur in our waters, but of which no specimens had so far been preserved, while a few were entirely new to the collection. The following list contains their description.

Yours very respectfully,

OTTO LUGGER.

XIIa—GADIDÆ.

PHYCIS, Raf.

P. tenuis.

The Slender Cod.

The body of this fish is moderate in length, and is covered with small scales. Eyes of moderate size. Mouth and palate furnished with small sharp teeth ; those on the vomer in an angular band. Tongue smooth. Beneath the chin a small barbel. Vent nearer the head, tail rounded. Lateral line curved upward. The fins are enveloped in a loose skin ; it has two dorsal fins, the anterior composed of 11 rays ; the ventrals are reduced to a single long ray, bifid at its end. The throat is internally streaked with red and purple. Back and sides brown, lighter below. Fins dark brown except the ventrals, which are whitish with red extremities. Length, 15 inches.

Fin-rays :—D. 11, 54 ; V. 1 ; P. 16 ; A. 44 ; C. 25.

Phycis tenuis, Mitchel.

A single specimen of this fish was caught in early November near Ocean city, but being kept too long by the fisherman as a curiosity, it was impossible to preserve it in the collection.

XXVIII—SCIÆNIDÆ.

OTOLITHUS.

O. nothus.

The Bastard Trout.

The height of the body is $4\frac{1}{2}$ in the total length, the length of the head $3\frac{4}{5}$. The form of this *Otolithus* differs from that of the *Cynoscion regalis* (our common sea-trout,) in being shorter and thicker in proportion, and more arched along the back ;

the head, too, is smaller, the snout shorter, and the lower jaw more pointed. The eye is very large, and is less than its diameter from the snout. The nostrils are double; the posterior is larger, oval, elongated, nearly vertical, and on a plane rather below the upper margin of the eye, and at the anterior extremity of the supra-orbital ridge; the anterior is circular, and very near the posterior. The mouth is large, with thin lips; the upper jaw is very protractile, and armed with a double series of small, conical, pointed teeth; in front, and between these rows, but belonging to neither, though nearest the posterior, are two large canine teeth, conical, pointed, recurved and directed backwards. The lower jaw has a double series of minute, pointed teeth in front, while behind there is only a single row, and the teeth are larger. The tongue is large, flat, rounded and free in front. The preopercle is rounded at its angle, with a crenated margin. The opercle terminates in two minute, flattened points. The anterior dorsal fin begins behind the root of the pectoral, and has eight spinous rays, received in a sheath; the second and third being longest. The posterior has one spinous and 28 soft rays; the first very short and closely joined to the second; the scales ascend high up on its roots, and make a partial sheath. The pectoral is small, arising at the termination of the opercle. The ventral is short, but tolerably broad. The anal is short; it has one delicate spinous and nine soft rays. The caudal is moderately broad, nearly straight behind. The lateral line runs along the upper fourth of the body as far as the second dorsal, where it curves down to the median plane, and continues to the end. The whole animal is silvery white except the fins, which are more or less yellowish; the pupil is deep blue, and the iris golden gray. Total length, 12 inches.

Fin-rays:—D. 8, 1, 25; P. 16; V. 1, 5; A. 1, 9; C. 18.

O. nothus, Holbr. Ichth. S. Car., p. 134, pl. 19, fig. 1.

This is an uncommon fish, that belongs to the southern waters. Two specimens were taken with hook and line in

Spring Garden, near Baltimore. The fishermen did not know the fish, but thought they might be young California Salmon Trout.

ACAD. COLLECTION.

XXXIII—PERCIDÆ.

ENNEACANTHUS. Gill.

E. obesus.

Striped Sun-fish.

The general form of this Sun-fish is subelliptical, the head being of a perfect continuity with the dorsal and abdominal line of the body. Peduncle of the tail short. Greatest depth about the middle of the length, the caudal fin excluded. Mouth rather small, and its cleft, when shut, obliquely directed upwards. Dorsal fin composed of nine spinous and eleven soft rays, the latter being elongated, the posterior ones extending beyond the base of the caudal. The anal has three spinous and eleven soft rays, the posterior ones extending likewise beyond the base of the caudal. Caudal fin posteriorily rounded. Ventral fins inserted a little in advance of the pectorals; their tips extend beyond the anterior margin of the anal. The pectorals are subelliptical, rounded posteriorily, and extend as far back as the ventrals, i. e., to beyond the anterior margin of the anal. The scales are proportionally larger, and are disposed upon sixteen rows across the line of the greatest depth, and eight or nine rows on the peduncle of the tail. The lateral line forms a regularly arched curve from the upper angle of the opercle to beneath the posterior margin of the dorsal fin, thence almost straight, and very obsolete, to the base of the caudal. The ground color is light, transparent olive, with five or six black bands. A tinge of rose color on the posterior part of the abdomen Scales generally with a V-shaped gold marking, smaller and

more like a spot, on the peduncle of the tail. Iris reddish-brown, with a vertical bar of brown. A large and subcircular black patch is observed at the upper angle of the operculum, extending over the gill-flap, upon which a double crescent is seen; this is golden at the base, with a horizontal blue or golden line below. Length, 3 to 4 inches.

Fin-rays:—D. 9, 11; P. 11; V. 1, 5; A. 3, 11; C. 17.

Pomotis obesus, Girard Proc. Bost. Soc. Nat. Hist. V, 1854, p. 40; Baird, Smiths. Rep. IX, p. 324.

This pretty little Sun-fish is very common in the dark-colored streams of Worcester county. Though confining itself usually to the muddy creeks, it is often found in clear water, but in such case, frequents only such places where the different water-plants grow very luxuriantly.

Enneacanthus chætodon, Baird, and *E. margarotis*, Jord., occur in similar places; the little Mud-fish, *Umbra pygmæa*, (DeKay), Bean., frequents also these dark, sluggish or stagnant streams, burrowing into the mud.

Acad. Collection.

XXXIIIa—ETHEOSTOMATA, Agass.

BOLEICHTHYS.

B. erochrous.

Mud-Loving Darter.

The length from the opercle to the tip of the tail is equal to 4 heads; the greatest elevation without the dorsal fin is three-fourths of the head. This small fish has an elongated, slender and compressed body, which is thicker below than above. The head is small, short, compressed, narrow between the eyes, with a rounded and full snout, though not so broad as the occiput; it is smooth above, though covered with scales on the sides. The eye is very large, and is placed half the diameter of its orbit from the snout, and two diameters from the angle

of the opercle, with its inferior margin below the median plane of the head, and its superior at the facial outline. The posterior nostril is very near the eye, at the end of the superciliary ridge. The mouth is small, hardly reaching to the eye; the lower jaw is nearly as long as the upper, though its teeth are received within it when the mouth is shut; both are armed, as well as the vomer and pharyngeal bones, with numerous, minute, closely set, pointed, recurved teeth. The preopercle is so rounded as to present no angle; the opercle is small, triangular, with its base before and its apex behind, and is armed with a slender, delicate spine; the interopercle and subopercle are large. The lateral line runs along the superior fourth of the body, to the end of the anterior dorsal fin, whence it gradually descends to the median plane of the tail. The anterior dorsal fin begins in a line vertical with the anterior third of the pectoral, extends to the vent, and has ten spines; the posterior is more elevated, and has eleven rays. The pectoral arises a little behind the opercle and extends to the root of the ninth dorsal spine; it is slender, and has twelve rays. The ventral begins at some distance behind the origin of the pectoral fin, but extends beyond it; it is long, slender, with one delicate spine and five soft rays. The anal begins slightly behind the origin of the posterior dorsal fin, and determines with it behind; it has ten soft rays. The caudal is long, narrow, and rounded behind. Head with greenish tints at the opercle; body above pale brown; belly white; a longitudinal row of rounded dusky spots on the sides. The second dorsal and anal fins have dusky points arranged in lines. Total length, 2 to 3 inches.

Fin-rays:—D. 10, 11; P. 12, V. 1, 5; A. 10; C. 14.

Boleosoma Barrattii, Storer.

This little fish resembles very much the "Tesselated Darter" (*Boleosoma olmstedi*, Storer) in appearance, but frequents entirely different haunts. Instead of living in clear streams with rocky beds, it is found in the dark, sluggish creeks of Worcester County, settling on the black mud found

there. It belongs to the more southern fauna, having been first described from S. Carolina and Florida.

ACAD. COLLECTION.

XXXIIIb--APHREDODERIDÆ.

APHREDODERUS.

Since but one single fish forms this family, it is well to define the characters, quoting them from Guenther.

Cleft of the mouth slightly oblique, with the lower jaw longest; eye moderate. Villiform teeth in both the jaws, on the vomer and on the palatine bones. Six branchiostegals. Infraorbital and præoperculum with spinous teeth. Scales moderate, etenoid. Dorsal with three, anal with two spines. Caudalis rounded.

A. sayanus.

The Spineless Perch.

The height of the body is $4\frac{1}{3}$ in the total length, of which the head is one-fourth; the diameter of the eye is less than the distance from the end of the snout, and two-thirds of the distance between the eye. The body is oblong, thick and sub-compressed; the back is elevated, descending with an equal curve from the soft rays of the dorsal to the nape. From 45 to 50 scales are in a longitudinal series; they are small, rough, rounded and ciliated. The lateral line is but slightly curved, almost straight, passing near the middle of the body. The head is flattened above. A bony crest, supporting two or three spines, which are continuous with the denticulated crest of the upper margin, is on the anterior portion of the sub-orbital, so that the lower margin of the orbit is smooth, while the upper two-thirds of the margin is rough; a longitudinal furrow is formed by two crests. The

wide preopercle is finely denticulated, with rounded angle, and covered with six rows of scales. The large opercles are scaly, with a smooth margin, and with a short, robust spine near the angle. The eyes are moderately large. The nostrils double; the one near the margin of the orbit is large, the anterior one smaller and tubular. The lower jaw is longest; numerous conical incurved teeth in both jaws, upon the anterior part of the vomer, palatines and pharyngeals. The smooth tongue has a free and rounded end. The vent is placed at the angle formed by the fold of the branchial membrane. The high dorsal fin is placed in the middle third of the body; it has three spinous, and eleven nearly subequal branched rays, of which the last is somewhat smaller; the ventrals are slightly behind the base of the pectorals, and contain no spinous rays; the caudal is rounded, nearly even. Greenish olive, with a vertical spot beneath the eye. Length, 3-4½ inches.

Fin-rays:—D. 3, 11; P. 12; V. 0, 7; A. 3, 7; C. 17.

A. sayanus, Gilliams.

Scolopsis sayanus, Gilliams' Jour. Ac. Nat. Sc. Ph. IV, p. 81, pl. 3.

Aphredoderus gibbosus, Cuv. & Val. IX, p. 448, pl. 278.

" *sayanus*, DeKay, New York Fauna, Fishes, p. 35, pl. 21, fig. 62; Baird, Ninth Smith's Rep., p. 326.

This peculiar perch-like fish inhabits the fresh and brackish waters of Turner's creek, near Berlin, Worcester county. It loves dark streams with muddy bottoms, on which it settles, darting away with great vigor when disturbed. Shallow places, heated by the hot rays of the sun, form the desired resorts.

Acad. Collection.

XL.---GASTEROSTEIDÆ.

GASTEROSTEUS. (L.) Brev.

G. noveboracensis.

New-York Stickleback.

This pretty little fish has a fusiform, compressed body, the sides of which are covered with a series of from 30 to 33 transverse plates. The prominent lateral line is concurrent with the back, but at about the nineteenth or twentieth lateral plate it becomes elevated into sharp, compressed spines, that form a distinct ridge along each side of the tail. The small head is covered with striate bony plates, flattened above, and sloping in a straight line from the nape. The mouth, which is slightly protractile, has a vertical aspect; the lower jaw is longest. Eyes large. Minute subequal teeth in a single row on each jaw; none elsewhere. Tail very slender. The first dorsal spine is acute, placed above the base of the pectoral, and has a broad base; it is serrated on the sides, and furnished with a membrane. The dorsal spine is long, the first ray is largest, the others gradually decrease in length to the last. Pectorals long and rounded. The place of the ventral is supplied by a single ray on each side, reaching to the posterior extremity of the pubic bone; it has a dilated base, and is distinctly toothed on its side. Under each ventral spine is a soft flexible spine. The anal fin is long, slightly emarginate, with one curved spine. Caudal fin emarginate. Bluish-gray above, silvery on the sides and beneath. Length, 2 inches.

Fin-rays:—D. 1+1+1, 12; P. 11; V. 1, 1; A. 1, 12; C. 13.

Gasterosteus noveboracensis, Cuv. & Val., IV, p. 502, pl. 98, fig. 3; DeKay, New York Faun. Fish, p. 66, pl. 6, fig. 17.

But a single specimen of this Stickleback was taken in the northern part of Sinepuxent bay, in a place where the water was but little brackish. On account of the very luxurious growth of water-plants, it was impossible to haul the fine-

meshed seines with any success; no doubt, however, that these fish build their peculiar nests in such a place. The common "Four-spined Stickleback" was here also very numerous, but choosing the more shallow water.

L. ELOPIDÆ.

ELOPS, Linn.

E. saurus.

Big-Eyed Herring, Jackmariddle, or Pounder.

The entire length, from the opercle to the tip of the caudal fin, is equal to four heads and one-eighth. Body very much elongated, sub-cylindrical, round at the back, slightly flattened at the belly, and as slightly compressed at the sides, but much more so near the tail, the head is long and thick, with the snout full and rounded; the supra-orbital ridges are elevated, and leave a deep, broad, oblong depression on the vertex, which is broadest between the eyes, and very narrow behind; the orbit of the eye is marked above with parallel ridges and depressions, directed from within outwards. The eye is very large and placed near the facial outline, with its inferior margin below the median plane of the head, and about its diameter from the snout, and two diameters and a quarter from the posterior border of the opercle; it has a thick, fleshy lid of diaphonous skin, both before and behind. The nostrils are closely approximated, and rather nearer to the eye than to the snout; the posterior is semi-lunar in shape, and much the larger; the anterior is round, and both are at the anterior extremity of the supra-orbital ridge. The mouth is very large, as the posterior extremity of the upper jaw extends behind the orbit; the lower jaw seems larger than the upper when the mouth is open, but is in fact received within it when the mouth is closed; the upper jaw has no lip, but the lower has a loose fold of skin on its posterior half; both are

armed with numerous series of minute, rasp-like teeth ; the band in the inter-maxillary is narrow, that of the superior maxillary is rather broader, and extends on the outer as well as the inner margin of the bone ; the band of the lower jaw is narrow behind, and broad before ; the vomer, the palate, the sphenoidal, and the pharyngeal bones are all furnished with similar minute teeth ; even the anterior margin of the branchial arches is rough with minute asperities. The tongue is short, round in front, and rough on its posterior part with minute teeth. The dorsal fin is single, semi-falcate, near the middle of the back ; the first ray is very short, the 4th, 5th and 6th longest ; they are placed in a scaly sheath of the integuments, which ascends for some distance, but without any adhesion. The pectoral begins under and in front of the termination of the opercle, with an elongated scale in the axilla above. The ventral is stout, and arises rather before the origin of the dorsal ; it has a supplementary plate above the rays, three-fourths as long as the fin itself, and covered with scales. The anal is short, sub-falciform. All have their roots in a sheet, like those of the dorsal fin. The caudal is long, deeply forked, with a lanceolate flattened scale both above and below its root. The scales are but slightly adherent and exceedingly thin. The lateral line at its anterior part is straight, and runs nearly along the upper third of the body, but it descends to the median plane between the pectoral and ventral fins. The head is pale green above, and white with often a roseate tint at the sides ; the body is pale silver-gray above, or with a faint greenish tint, and silvery at the sides and belly. The pupil is deep blue, and the iris silvery. Total length, 24 to 30 inches.

Fin-rays :—D. 24 ; P. 18 ; V. 15 ; A. 17 ; C. 28.

E. saurus, L. Syst. Nat. 1, p. 518 ; Bloch, Taf. 393, fig. 1 ; DeKay, New York Fauna, Fish, p. 267, pl. 41, fig. 131 ; Cuv. & Val. XIX, p. 365.

—*inermis*, Mitchell, Lit. & Phil. Trans. New York, I, p. 445.

A very large specimen of this fish was caught in the southern part of Chesapeake Bay. It is a voracious animal, that feeds on smaller fish. The flesh, both lacking firmness and flavor, is not esteemed as an article of food.

ACAD. COLLECTION.

MEGALOPS, Lac.

M. thrissoides.

Jew-fish. Tarpum.

This largest of all the Herrings has a compressed, oblong body, with a flat abdomen. The snout is obtusely conical; the mouth anterior, lower jaw prominent. The intermaxillary is short, the maxillary forms the lateral part of the mouth, and extends beyond the orbit. Between the mandibles is a narrow osseus lamella, attached to the mandibulary symphysis. The mouth is furnished with three bands of villiform teeth in the jaws, with teeth on the vomer, palatine and pterygoid bones, on the tongue and on the base of the skull. The gill-membranes are entirely separate, with numerous branchiostegals. The scales are very large and adherent. The lateral line is distinct, and runs in an almost straight line along the upper third of the body. The ventral fin is conspicuously in advance of the origin of the dorsal fin; the anal is rather longer than the dorsal. The long ray, the last of the dorsal fin, forms a very conspicuous character of this fish. The general color is beautiful silvery, darker on the back. Length, 4 feet 3 inches.

Fin-rays:—D. 17; P. 15; V. 10; A. 25; C. 30.

Megalops thrissoides.

Clupea cyprinoides, Bl. IX, p. 32, tab. 403; Lacep. V, pp. 424, 461.

Clupea thrissoides, Bl. Schn., p. 424.

— *apalike*, Lacep. V, pp. 425, 461.

— *gigantea*, Shaw, Zool. V, p. 173.

Megalops atlanticus, Cuv. & Val. XIX, p. 398.

This large fish, looking—if it was not so much more slender—like a overgrown Mud-Shad, (*Clupea thrissa*), was caught in the Chesapeake bay, near Crisfield. "Marcgraw assures that it attains the length of twelve feet, and the thickness of a man. The mouth, when it is opened, is so large that the head of a man could easily enter it; it is very fat, and only the flesh of very young fish can be utilized as food."

Acad. Collection.

LXVIa—SQUATINIDÆ.

SQUATINA, Dum.

S. dumerili, Les.

Angel-fish. Shark-ray. Monk.

This peculiar fish, combining the characters of a *shark* with those of a *ray*, has a broad flattened body, which is elevated towards the pectorals. The head is wider than long, obtuse, emarginated in front between the nostrils, depressed above and between the eyes; it is bordered on each side by a white membrane. Neck rather tumid and distinct. Eyes small; orbit elevated, and furnished with blunt tubercles; similar ones above the nostrils and between the spiracles. Cheeks flat, with numerous pores. Nostrils with skinny flaps on the margin of the snout; they are on the anterior edge, above the jaws, and between the eyes; aperture vertical, and covered by a broad membrane. Spiracles behind the eyes, wide, transverse. Teeth conical, pointed and distant, in six to seven distinct series. Gill-openings rather wide, lateral, very near each other, and partly covered by the base of the pectorals. Tongue triangular, flat, not distinct, terminated by a small fleshy rounded appendage. The subtriangular pectoral fins are large, expanded in the plane of the

body, with the basal portion prolonged forwards, but not grown to the head; they have a round notch at their inner base, and curved sharp points on the upper surface of their outer margin. Abdominal fins lanceolate, straight, narrow. The two dorsal fins are triangular, subequal in size, and situated on the base of the tail. Caudal fin emarginate; lower lobe longest, both pointed. Bluish ash-gray above; beneath white. Abdomen, throat and ventral fins marked, when living, by indistinct red spots. Eyes yellowish-green; pupils black. Length: 3 to 4 feet.

Rhina squatina, Guenther Cat. VIII, p. 430.

Squalus squatina, L. Syst. Nat. I, p. 396; Brunn. Ichth. Mass., p. 5; Bl. Ausl.; Fisch. I, p. 25, tab. 116.

Squatina lævis, Cuv. Regne Anim.

— *aculeata*, Cuv. Regne Anim.

— *angelus*, Dumeril, Zool. Anal., p. 102.

— *dumerilii*, Lesueur, Jour. Ac. Nat. Sc. Phil. I, p. 225, pl. 10; DeKay, New York Fauna, Fish, p. 363, pl. 62, fig. 203.

This fish is an inhabitant of most of the temperate and tropical seas. Its curious form make it conspicuous among the many inhabitants of the ocean, that are caught late in the fall on the coast of Worcester county. The not very inviting looks of the fish are not the only reasons why fishermen dislike it. It has, to some extent, the unpleasant habits of the snapping turtle, since it can open its mouth very suddenly to an alarming extent, and not to play, either. In consequence of this biting propensity, it is called by the fishermen the "Sand-devil," and also the "Fair-maid;" the first name not without any reason, and the latter certainly not out of politeness. It is a very common fish during late October and early November, sometimes obstructing by their numbers the successful hauling of seines.

Acad. Collection.

LXVII—LAMNIDÆ.

ISUROPSIS.

I. dekayi.

The Mackerel Porbeagle.

Body cylindrical, fusiform. Head small, with a blunt pyramidal snout; the præoral portion of the latter as long as the longitudinal axis of the cleft of the mouth, tetrahidal, pointed. Angle of the mouth midway between the gill-opening and nostril. The surface of the head exhibits, under the lens, numerous minute plates, each with three parallel longitudinal elevated lines, producing a roughness when the hand is moved towards the head. On the surface of the head are four series of punctures on each side, commencing nearly opposite to the posterior margins of the orbits, dilating and extending to within about an inch of the extremity of the snout. Immediately before the eyes is a large patch of similar punctures, which extend beyond the nostrils; on the under-side of the snout is a triangular patch of similar punctures, extending to nearly the extremity; a regularly curved series of punctures from the end of the carina, concurrent with the back, and ending just anterior to the origin of the first dorsal fin. All these punctures are the apertures of mucous ducts, which are filled with a transparent jelly. Eyes moderate; nostrils doubly curved, sublateral. Gill-openings extremely wide, the width of the first being rather more than its distance from the last. Teeth of various shapes and sizes, disposed in from three to five rows. They are mostly long lancolate, with sharp lateral edges, without basal cusps. The third tooth on each side of the upper jaw is much smaller than those next to it. The first dorsal fin, which has its origin at a very short distance from the base of the pectorals, is quadrilateral, higher than long; its upper margin is excavated, its lower angle pointed. The second dorsal fin is very small, oblong; its lower angle behind end-

ing in a prolonged point. The pectorals are falciform, the length of their lower margin being one-fourth of that of the upper. Ventrals quadrilateral; the anal fin is small, similar in shape to the second dorsal and sligtly posterior to it. The caudal fin is deeply lunate, with slightly unequal lobes. On each side of the tail is a carina, highest in the middle; a deep dentation occurs on the upper and lower sides of the tail. When first taken from the water, the color of this fish is deep green, which soon changes into a uniform dark slate, lighter beneath. Length: 5 to 10 feet.

Lamna punctata, Storer, Bost. Jour. Nat. Hist. I, 1839, p. 534, pl. 8, fig. 2; DeKay, New York Faun., Fish, p. 352, pl. 63, figs. 206 and 207.

Oxyrhina gomphodon, Mull. and Henle, p. 68, pl. 28.

Isuropsis DeKayi, Gill, Ann. Lyc. Nat. Hist. New York, VII, p. 409.

A common fish along the coast of Worcester county during the summer.

Acad. Collection.

TABLES.

RECORD OF DISTRIBUTION OF CALIFORNIA SALMON,

Made from January 30th to December 10th, 1877, by Maryland Commission of Fisheries, under direction of T. B. Ferguson, Commissioner.

Date.	Obtained from.	Place whence taken.	Number of Fish. Originally Taken.	Number of Fish. Actually Planted.	Introduction of Fish. Place.	Introduction of Fish. Stream.	Introduction of Fish. Tributary of—	Transfer in charge of—	
1877.									
Jan. 30	Com. of Fish & Fisheries.	Hatching House.	4,000	4,000	Near Monkton.	Gunpowder.	Gunpowder.	Wm. Hamlen.	....
30			10,000	10,000	5 miles f'm do	Little do	do	do	....
Feb. 1			14,000	14,000	Cherry Run.	Potomac.	Potomac.	do	....
Mar. 19			800	800	Harford Co.	Winter's Run.	Bush.	Watersville F. Club	Watersville Farmers' Club.
April 11			50	50	....	Private pond.	....	Alex. Rieman.	Alex. Rieman.
May 8			2,000	2,000	Near Deer Park	Youghiogheny.	Ohio.	J. H. Hines.	Senator Davis.
29			50	50	....	Private ponds.	....	Mr. Irwin.	Mr. Irwin.
31			50	50	....	do	....	H. H. Grine.	H. H. Grine.
June 4			50	50	....	do	....	John Wethered.	John Wethered.
Total. . .			31,000	31,000					From Eggs of October, 1876

Distribution of California Salmon from Eggs of October, 1877.

Nov. 19	Spencer F. Baird, U. S.	Druid Hill	30,000	29,500	Ft. Pendleton.	Potomac River	Potomac.	Wm. Hamlen.	....
22			15,000	15,000	Piedmont.	do	do	do	....
22			12,000	12,000	Swantown.	Savage River.	do	do	....
Dec.			10,000	10,000	....	....	....	H. B. Miller,	Fish Commissioner of W.Va.
5			25,000	25,000	Sir John's Run	Potomac River	Potomac.	Wm. H. Hines.	....
7			20,000	20,000	Phœnix.	Gunpowder do	Gunpowder.	do	....
10			8,000	8,000	Tank Station.	Patuxent do	....	do	....
Total....			120000	119500					From Eggs of 1877.

RECORD OF DISTRIBUTION OF BROOK TROUT,

Made from February 19th to May 8th, 1877, by Maryland Commission of Fisheries, under direction of T. B. Ferguson, Commissioner.

Date.		No. of Fish.	To whom Given.	INTRODUCTION OF FISH	
				Stream.	Place.
1877.					
Feb.	19	8,000	A. B. Davis.	Streams of Montgomery County.	Montgomery County.
	22	1,500	McHenry Howard.	Tributary of Gunpowder river.	Baltimore County.
	27	1,500	J. S. Gittings.	do do	do
	27	2,000	Geo. N. Moale.	do do	do
Mar.	1	3,000	D. S. Gittings.	do do	do
	2	1,500	Geo. W. Mills.	Tributary of Patuxent river.	Howard County.
	2	1,000	J. M. Pearce.	Tributary of Gunpowder river.	Baltimore County.
	3	1,000	Wm. Collins.	Tributary of Choptank river.	Talbot County.
	3	3,000	R. Norris.	Tributary of Patapsco river.	Baltimore County.
	3	2,000	S. H. Tagart.	Tributary of Gwynn's Falls.	do
	6	1,000	B. S. Ford.	Tributary of Chester river.	Queen Anne's County.
	6	1,000	Howard Ridgeley.	Tributary of Gunpowder river.	Baltimore County.
	6	1,000	Samuel Appleby.	Tributary of Patuxent river.	Howard County.
	6	500	C. Ax.	Private pond.	Baltimore County.
	7	1,000	G P. Whitaker.	Principie creek.	Cecil County.
	8	1,500	John Donaldson.	Patapsco river.	Howard County.
	8	1,000	A. G. Woodward.	Patuxent river.	Anne Arundel County.

Mar.	9	3,000	W. Polk.	Tributary of Pocomoke river.	Somerset and Worcester Counties.
	10	1,000	A. G. Cummings.	Little Morgan run.	Carroll County.
	12	3,000	A. R. McGraw.	Susquehanna river.	Cecil County.
	13	500	Louis Hammersla.	Pond.	Washington County.
	15	1,000	W. S. Kennedy.	Tributary of Chesapeake Bay.	Howard County.
	15	1,000	D. W. Taylor.	Tributary of Bush river.	Baltimore County.
	17	1,000	Jas. T. Earle.	Tributary of Corsica creek.	Queen Anne's County.
	19	1,500	Watersville Farmers' Club.	Winter's run.	Harford County.
	19	1,000	H. S. Willis.	Tributary of Deer creek.	do
	23	300	Jno. W. Hanson.	Streams of Howard County.	Brook Trout, from California, (Salmo Iridia.)
April	13	750	J. Spencer.	Gunpowder river.	Baltimore County.
	17	1,000	J. B. Stake.	Pond.	Washington County.
	17	1,000	J. H. Farrow.	Shooting run.	do
	18	2,000	A. Boyle.	Deep run and Broad creek.	Harford County.
	19	200	Jesse Tyson.	Private pond.	Baltimore County.
	24	400	Mrs. Henry Wilson.	do	do
May	8	330	Senator Davis.	Pond at Deer Park.	Garrett County.
		50,480			

RECORD OF SMELT HATCHING OPERATIONS,

Conducted at New Brunswick, New Jersey, from March 3d to April 5th, 1877, *on account of Maryland Fish Commission, by T. B. Ferguson, Commissioner.*

Day.	Date.	Temperature of— Air. 6 A. M.	Air. 12 M.	Air. 6 P. M.	Hydrant. 6 A. M.	Hydrant. 12 M.	Hydrant. 6 P. M.	River. 6 A. M.	River. 12 M.	River. 6 P. M.	Ripe Fish. Males.	Ripe Fish. Females.	Number of Eggs obtained.	Remarks.
	1877													
Sat.	March, 3										7	2	40,000	
Sun.	4										0	0		
Mon.	5										6	4	90,000	
Tues.	6	27	32	31	38	38	38	37	39	39	16	3	65,000	
Wed.	7	32	47	45	38	38	38	37	40	41	3	1	15,000	Sent 605 large Smelt to Salisbury, Md., by Geo. T. Finley.
Thurs.	8	36	61	59	38	39	39	38	42	49	0	0		
Fri.	9	57	43	32	39	39	39	47	49	48	2	1	25,000	
Sat.	10	24	36	25	39	39	39	41	42	41	0	0		
Sun.	11	32	44	35	39	39	39	36	42	40	12	1	30,000	
Mon.	12	35	41	43	39	40	40	38	39	40	5	2	50,000	
Tues.	13	37	39	39	39	39	39	39	40	39	0	0	Freshet.	

Wed.		14	33	38	38	41	40	40	39	39	39	0	0	Freshet.
Thurs.		15	26	36	36	39	40	39	38	40	39	7	5	150,000
Fri.		16	33	34	33	39	40	39	36	38	38	0	0	Freshet.
Sat.		17	28	30	24	39	39	40	36	36	35	0	0	do
Sun.		18	25	29	21	38	38	38	38	34	37	0	0	
Mon.		19	19	30	32	38	38	38	32	35	38	9	6	120,000
Tues.		20	29	32	31	37	38	38	32	35	38	0	0	
Wed.		21	34	49	44	38	38	38	35	36	38	0	0	Freshet.
Thurs.		22	43	46	43	38	38	39	37	38	39	0	0	
Fri.		23	42	55	62	39	42	39	40	40	42	5	15	275,000
Sat.		24	48	66	51	39	40	40	44	47	48	2	3	80,000
Sun.		25	40	39	44	40	41	45	40	42	46	0	0	
Mon.		26	41	42	43	41	41	44	41	42	43	0	0	
Tues.		27	41	51	44	41	42	43	41	44	45	2	4	90,000
Wed.		28	41	33	40	41	32	41	41	31	39	5	3	60,000
Thurs.		29	41	40	37	41	30	36	33	32	37	0	0	
Fri.		30	41	34	38	41	31	36	41	37	41	0	0	
Sat.		31	41	47	42	41	36	39	41	40	44	3	8	150,000
Sun.	April	1	41	40	44	41	46	44	41	46	45	0	0	
Mon.		2	42	53	46	41	45	45	42	44	46	3	11	200,000
Tues.		3	33	49	46	41	42	42	43	46	47			
Wed.		4	43	43	40	42	42	43	45	47	47			
Thurs.		5	41	44	41	42	43	43	45	46	46			
												87	69	1,410,000

April 21st, put young Smelt in Severn River.
" 22d, " " " Wye "
" 23d, " " " St. Michael "

A.—RECORD OF SHAD HATCHING OPERATIONS,

Conducted at "Head of the Bay," on the Chesapeake Bay, from May 4th, 1877, to June 13th, 1877, on account of United States and Maryland Commissions, by Jas. W. Milner, Deputy United States Commissioner, and T. B. Ferguson, Commissioner for State of Maryland.

Day.	Date.	Temperature of— at 12 M. Air.	Surface Water.	Bottom.	Direction of Wind.	Condition of Weather.	Ripe Fish—Males.	Ripe Fish—Females.	Eggs obtained.	No. Fish hatched	REMARKS.
Fri.	May 4	62		59	W.						Examined fish taken at Batteries above Susquehanna bridge. Milt bad.
Sat.	5	59		58	E.	Stormy.					
Sun.	6	60		56	Variable.	do.					Sunday no Seine Hauling.
Mon.	7	62		57	S.	do.	3	1			
Tues.	8	50		58	N. E.		7	11	180,000		
Wed.	9	62		56	Variable.		4	5	100,000		
Thurs.	10	56		57	N.W.		7	6	70,000		
Fri.	11	68		59	S.		4	3	25,000		
Sat.	12	62		57	S.		15	10	170,000		
Sun.	13	79		58	S.						Plenty of milt. Commenced to examine the fish taken on Spesutie Island Fisheries, and on North-East river. Eggs put in tank on steamer, and taken next morning to Havre de Grace.
Mon.	14	70		66	S.				1,250,000		
Tues.	15	71		70	S.		70	45	840,000		
Wed.	16	81		79	S.		47	41	700,000	200,000	

Thurs.	May	17	83	75	72	S.		88	41	735,000	785,000	
Fri.		18	85	78	74	S. W.		68	37	660,000	350,000	Surface water hot. Loss of eggs considerable.
Sat.		19	82	78	77	S.	— A severe storm in the night	83	34	460,000	2,047,500	
Sun.		20	84	78	77	N. E.		1	1	10,000	1,158,000	Heavy storm. Boxes overturned, and fish liberated.
Mon.		21	84	78	77	Variable.		60	23	460,000	110,000	
Tues.		22	83	78	73	N.W.		35	18	255,000		
Wed.		23	70	75	64	N.W.		20	10	145,000		
Thurs.		24	54	69	61	N.W.	Heavy gale.	4	5	100,000	153,000	
Fri.		25	60	63	65	N.W.	do	6	8	140,000	85,000	
Sat.		26	76	64	67	Variable.	do	3	4	60 000	50,000	
Sun.		27	70	65	66	S.	Calm.	25	38	417,000	50,000	Moved scows to Spesutie narrows.
Mon.		28	69	67	66	S.		28	46	735,000	60,000	
Tues.		29	73	71	66	S.		31	23	340,000	131,000	
Wed.		30	78	7 P.M 73	71	S.		13	29	490,000	290,000	
Thurs.		31	74	71	71	S.		7	16	332,000	661,000	
Fri.	June	1	78	74	71	S.		17	24	400,000	306,000	
Sat.		2	85	6 P.M 75	74	S. W.		20	27	465,000	327,000	
Sun.		3	83	77	77	S.		6	11	160,000	112,800	
Mon.		4	80	76	78	S.		6	10	145,000	360,000	
Tues		5	76	76	77	S. W.		1[illegible]	13	195,000	372,000	
Wed.		6	73	75	76	Chang'ble		4	6	95,000	128,000	
Thurs.		7	78	77	75	do		7	14	225,000	116,000	
Fri.		8	84	79	79	do		6	8	125,000	156,000	
Sat.		9	77	77	77	S.		2	4	55,000	76,000	
Sun.		10	69	76	73	S.W.		1	3	45,000	180,000	
Mon		11									100,000	
Tues.		12									44,000	
Wed.		13									36,000	
								709	575	10,584,000	8,444,300	

RECORD OF OPERATIONS

Of Jas. W. Milner, Deputy U. S. Commissioner, and T. B. Ferguson, Commissioner of Maryland, conducted at "Head of the Bay," in hatching and distributing young of Shad, (alosa sapidissima,) from May 8th to June 13th, 1877.

Day.	Date.	Eggs Taken.	Fish Hatched.	Stream.	Number.	Stream.	Number.	Stream.	Number.	Stream.	Number.
Sun.	May 8–13	545,000									
M.	14	1,250,000									
T.	15	840,000									
W.	16	700,000	200,000								
T.	17	735,000	785,000	Susquehanna.	200,000						
F.	18	660,000	350,000	do	785,000						
S.	19	460,000	2,047,500	do	350,000						
Sun.	20	10,000	1,158,000			North East.	3,055,500				
M.	21	460,000	110,000	do	50,000			Mississippi.	100,000		
T.	22	255,000		do	10,000			Oconee.	100,000		
W.	23	145,000									
T.	24	100,000	153,000			do	153,000				
F.	25	140,000	85,000			do	85,000				
S.	26	60,000	50,000			do	50,000				
Sun.	27	417,000	50,000			do	50,000				
M.	28	735,000	60,000			do	60,000				
T.	29	340,000	131,000					Alabama.	75,000		
W.	30	490,000	290,000	Spesutie Narrows.	46,000			Licking.	50,000		
T.	31	332,000	661,000	do	100,000	Elk.	150,000	Alabama.	100,000		
F.	June 1	400,000	306,000	do	56,000	Bohemia.	126,000	Potomac.	100,000	Upper Potomac.	150,000
S.	2	465,000	327,000	do	127,000	Sassafras.	285,000	Missouri.	100,000		

Sun.	3	160,000	112,800	Spesutie Narrows.	12,800						
M.	4	145,000	360,000					Missouri.	100,000	Big Black.	100,000
T.	5	195,000	372,000	do	100,000	Choptank.	510,000				
W.	6	95,000	123,000	do	72,000			Sacramento.	100,000		
T.	7	225,000	116,000	do	30,000			Patuxent.	160,000		
F.	8	125,000	156,000	do	50,000						
S.	9	55,000	76,000	do	20,000			Ocmulgee.	100,000		
Sun.	10	45,000	180,000	do	60,000						
M.	11		100,000	do	20,000						
T.	12		44,000	do	10,000	Nanticoke.	100,000	Wicomico.	100,000	Pocomoke.	100,000
W.	13		36,000	do	36,000			Wisconsin.	100,000	Gunpowder.	50,000
		10,584,000	8,444,300		2,134,800		4,624,500		1,285,000		400,000

PLATE I.

[NOTE.—It must be borne in mind that the figures of the following plates are more or less diagramatic, intending to bring out prominently things which are seen under the microscope very faintily, and at varying foci. The vitellus in Figs. 7, 9, 10 and 11, is either partially or not at all represented.]

Fig 1.—Unimpregnated ovum, freshly spawned, (page 58,) showing the micropyle in the center.

Fig. 2—Profile view of unimpregnated ovum, after being in water for a few moments, (page 59.) Micropyle shows as a distinct pit.

Fig. 3—Unimpregnated ovum, after the formation of the "limb," (page 60.) This stage occurs in both unimpregnated and impregnated ova.

Fig. 4—Impregnated ovum, showing stage preceding the "limbed" condition, (page 62.)

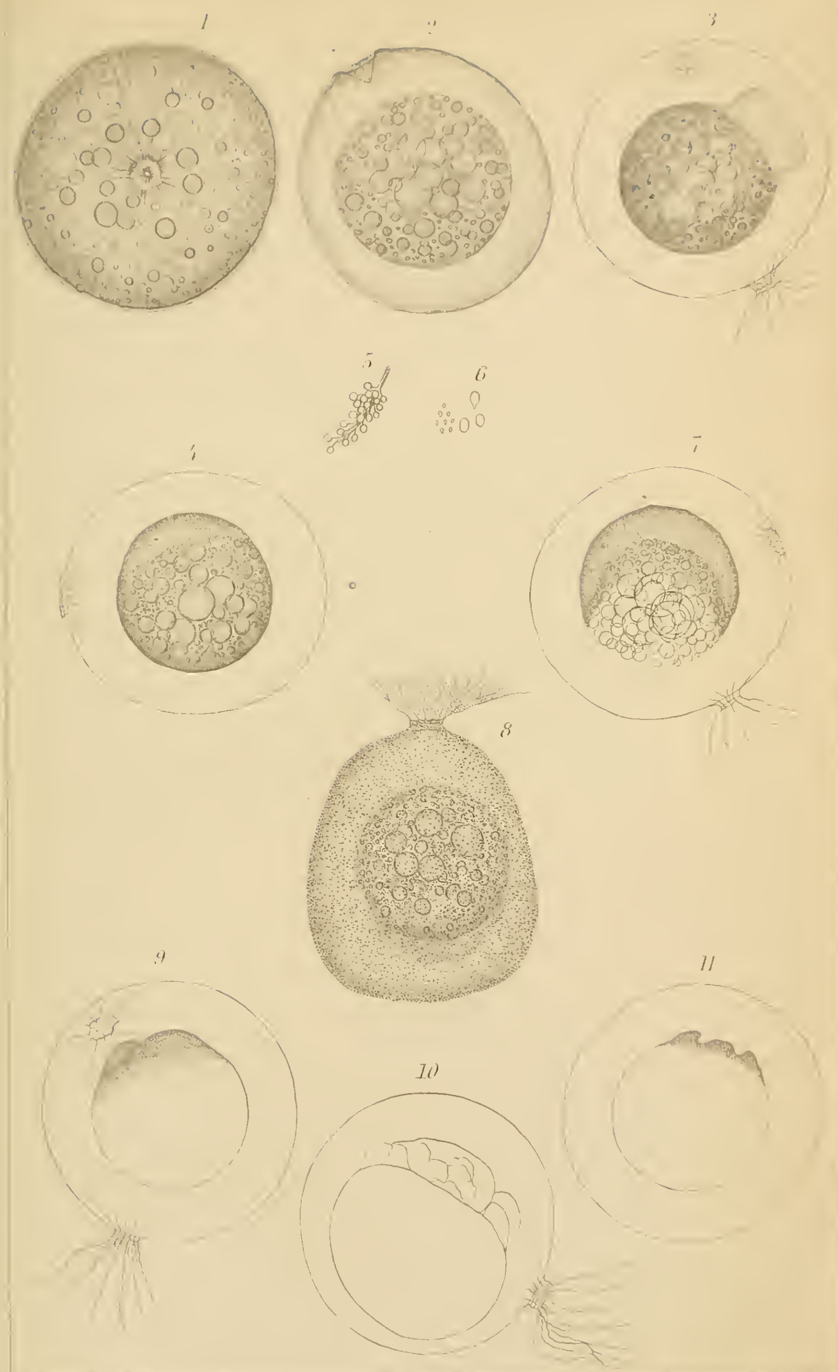
Fig. 5—Cluster of ova, natural size, (page 58.)

Fig. 6—Spermatozoa, (page 61.) Enlarged 950 diameters. Three very much more enlarged.

Fig. 7—Stage just preceding the formation of the dorsal laminæ, (page 62.)

Fig. 8—Showing the mucous oval sack, with its stalk, (page 58.)

Figs. 9, 10 and 11—Segmental stages of the ova, (page 62.)



1
3
5
6
7
8
9
10
11

PLATE II.

[The vitellus in most of these Figs. is unrepresented. The small dots beside certain of the figures show the natural size of the specimens.]

Fig. 1—Nearly profile view of embryo, showing anterior or head enlargement, (page 64.)

Fig. 2—Nearly profile view of embryo, showing cerebral vesicles, and still open anterior end of neural canal, (page 64.)

Fig. 3—Nearly profile view of embryo, showing eye-disks, (page 64.)

Fig. 4—Profile view of embryo, showing proto-vertebræ and traces of the notochord, (page 65.)

Fig. 5—Profile view of embryo; proto-vertebræ more advanced; ear, crystalline lens, and cerebellic fold showing, (page 66.)

Fig. 6—Face view of embryo, at a little later period than shown in Fig. 5, (page 66.)

Fig. 7—Nearly profile view of embryo, showing the rows of proto-vertebræ, one on each side of the neural arch.

Fig. 8—Exoderm cells, (page 63.)

Fig. 9—Head of embryo, showing parts of brain and eye-sacks, (page 66.)

Fig. 10—Profile view of brain, much enlarged, (63.)

Fig. 11 a, b, c,—Ear at different stages of development, (pages 66–7.) The otoliths are not represented.

Fig. 12—Face view of head, at stage represented in Fig. 4.

Fig. 13 a—Top view of a portion of the dorsum of an embryo, showing proto-vertebræ on each side the neural canal.

b—Cross section of dorsum of embryo, showing cells which surround the notochord.


1
2
3
4
5
6
7
8
9
10
11 a
b
c
12
13 a
b

PLATE III.

[The specimens represented in this plate were removed from the ova, and were about two-sixteenths of an inch in length.]

Fig. 1—Embryo before hatching; showing both ends of intestine, (page 68); the anal vacuole, (ibid); the ear with its otoliths; the heart and the branchial vesicles, (page 69.) The nasal pouch should be represented in this Fig. as a disk-like marking, just anterior to the eye, much as shown in Fig. 2.

Fig. 2—Earlier stage than Fig. 1. The intestine is represented by a posterior cæcum, (page 67); and the heart by a small pulsatile, pear-shaped organ, (page 67.)

Fig. 3—Enlarged view of the anal portion of Fig. 1, (page 70.) a—Indications of blood-vessel tracts. b—Anal vacuole.

Fig. 4—Profile of portion of embryo, showing tubular condition of the heart, (page 68.)

Fig. 5—In this Fig. the heart is represented as beginning to form two portions, (page 69); and the branchial vesicles are all visible, (page 69.)

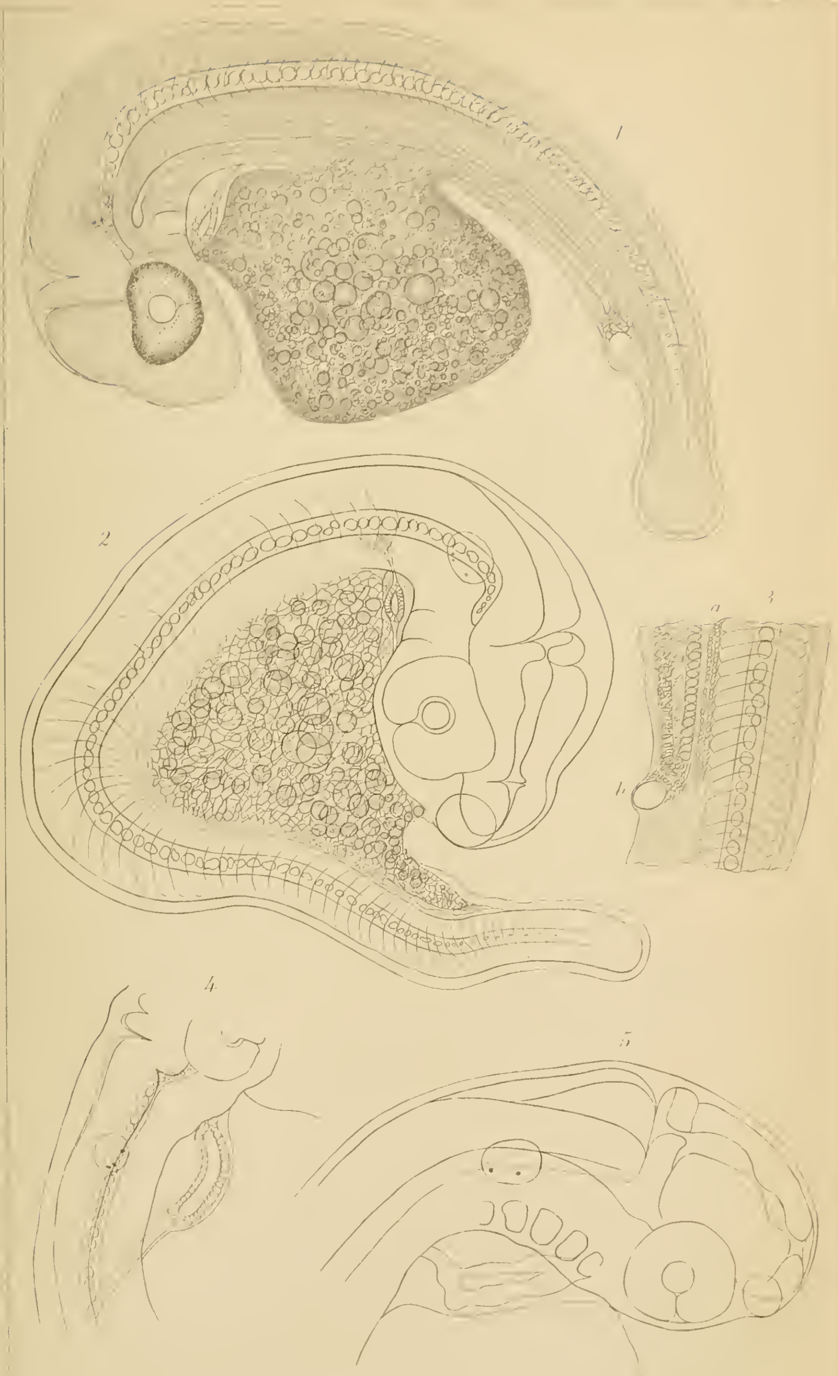

1
2
a
3
b
4
5

PLATE IV.

[The specimens represented in this Plate were also taken from the ova, and were from two to three sixteenths of an inch in length.]

Fig. 1—Showing the opening of the first branchial vesicle into the intestine, (page 69.)

Fig. 2—Nearly ventral view of anterior half of embryo, showing mouth opening, (page 70); and the semi-circular canals of the ear. In line seven, page 70, Fig. 4, Pl. IV, *should read* Fig. 2, Pl. IV. All the other organs of this Fig. are more advanced than in the other figures of this plate.

Fig. 3—Very much enlarged view of anterior end of embryo, viewed nearly ventrally. The ear is nearly enclosed; and the branchial slits, (page 69,) are formed.

Fig. 4—An earlier stage than Fig. 3. Three of the branchial slits are formed; the heart has become a two-chambered organ, (page 69); and a portion of the vitellus has concentrated into a large oil-sphere in the anterior part of the yolk mass, (page 69.)

Fig. 5—Posterior end of embryo. The portion under the notochord is splitting into two tracts, in which the great blood-vessels will soon be formed, (page 70.)

Fig. 6—Section of embryo in the anal region. The two tracts of Fig. 5 are seen, a and b, also the posterior end of the intestine, c, (page 70.)

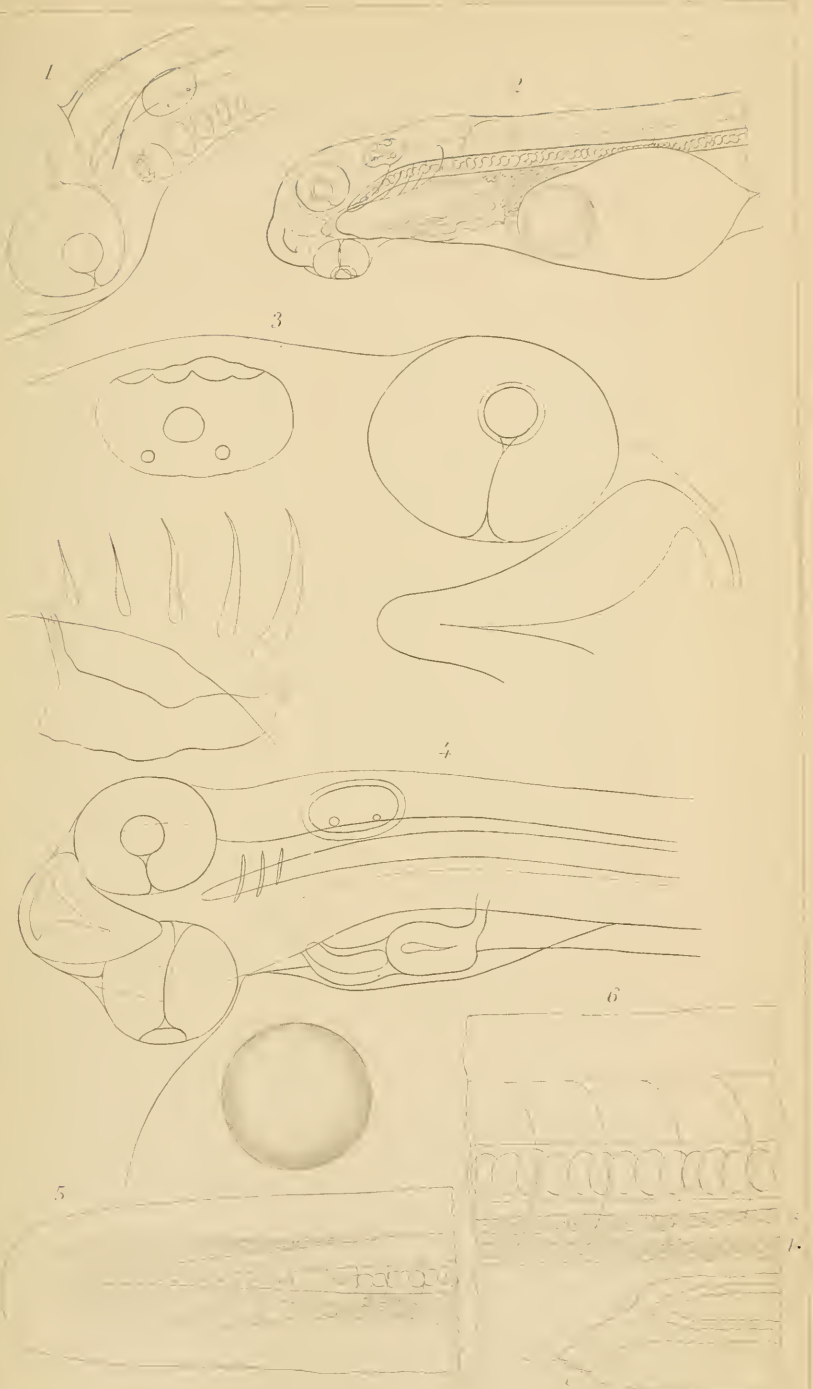

1
2
3
4
5
6

PLATE V.

[The figures represented in this Plate were from hatched specimens, and were, excepting the adult forms, about three-sixteenths of an inch in length.]

Figs. 1 and 2—Profile and dorsal views of recently hatched Smelt. All the organs already described can be made out in still more advanced condition, (page 71.)

Fig. 3—Diagram of first blood-system of young Smelt, (page 73.) The first and third pairs of branchial vessels are not represented in the diagram, since they are often, if not always, formed at a later period.

Fig. 4—Very much enlarged view of young Smelt, at a period a little later than represented in Fig. 1, (page 72.)

Fig. 5—Head of Smelt at time of first blood-system, (page 72.)

Figs. 6 and 7—Views of fast disappearing yolk. The large oil-sphere is in the centre of the mass, is becoming very much smaller, and has turned of a brownish-yellow color.

Fig. 8—Profile view of adult female Smelt full of ova. Raritan river form, natural size.

Fig. 9—Head of same, with extended jaws.

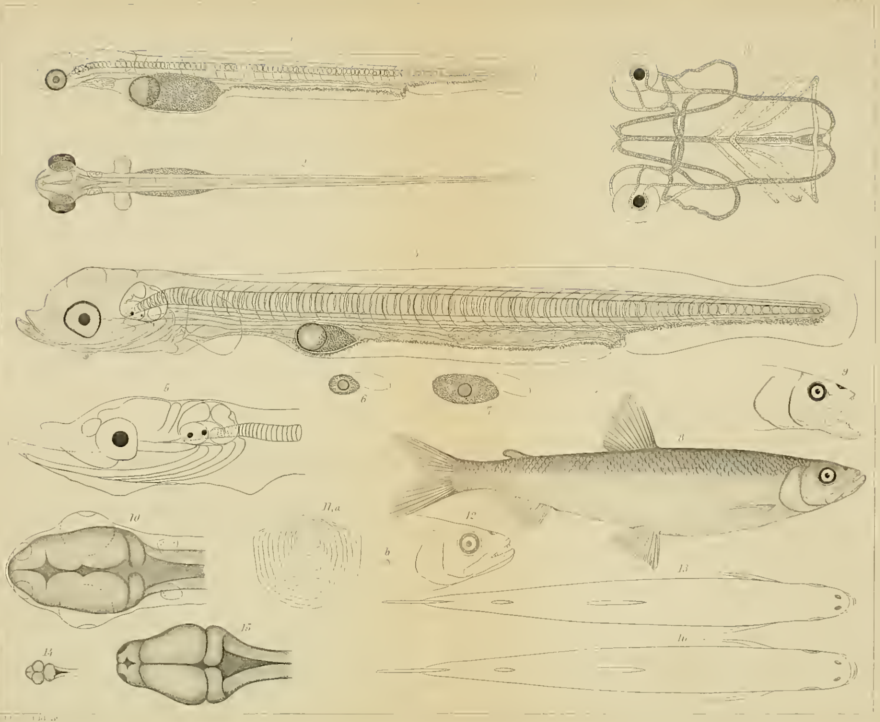
Figs. 10 and 15—Stages in the development of the brain, (page 71.)

Fig. 11a—Scale, much enlarged, from above lateral line of Raritan river fish. b—same, natural size.

Fig. 12—Head of Northern Smelt

Figs. 13 and 16—Dorsal views of Raritan river and Northern Smelts.

Fig. 14—Brain of Raritan river fish, natural size.



5
6
7
9
8
10
11,a
12
b
13
14
15

PLATE VI.

Fig. 1—Freshly spawned ovum of Shad, showing wrinkled and folded vitelline membrane, (page 97.)

Fig 2—Ovum after having been in water for a few moments, (page 98.)

Fig. 3—Unimpregnated or impregnated swollen ovum, showing first stage of formation of "limb," (page 98.)

Fig. 4—Impregnated ovum, showing marking indicating first segmentation furrow, (page 100.)

Fig. 5—Unimpregnated, or impregnated, swollen ovum, showing "limb," (page 98.)

Fig. 6—Impregnated ovum, showing first segmentation furrow and marking indicating second, (page 100.)

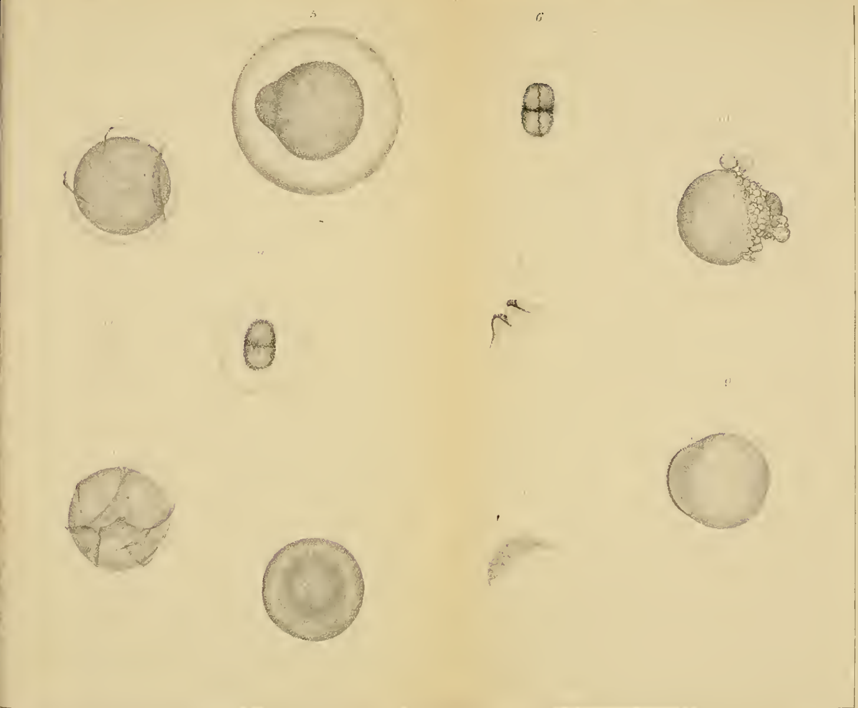
Fig. 7—Early stage of segmentation, (page 100.)

Fig. 8—"Mulberry" stage, (page 101.)

Fig. 9—Stage showing dorsal folds, (page 101.)

Fig. 10—One of the "irregulars," (page 104.)

Fig. 11—Ova natural size, (page 97.)



H. J. RICE, ad nat. del.